Bruce B. Hostetler

PROCEEDINGS

TWENTY-EIGHTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

Victoria, B.C.

March 1-3, 1977

Not For Publication

(For Information of Conference Members Only)

Prepared at

Oregon Department of Forestry

Salem, Oregon 97310

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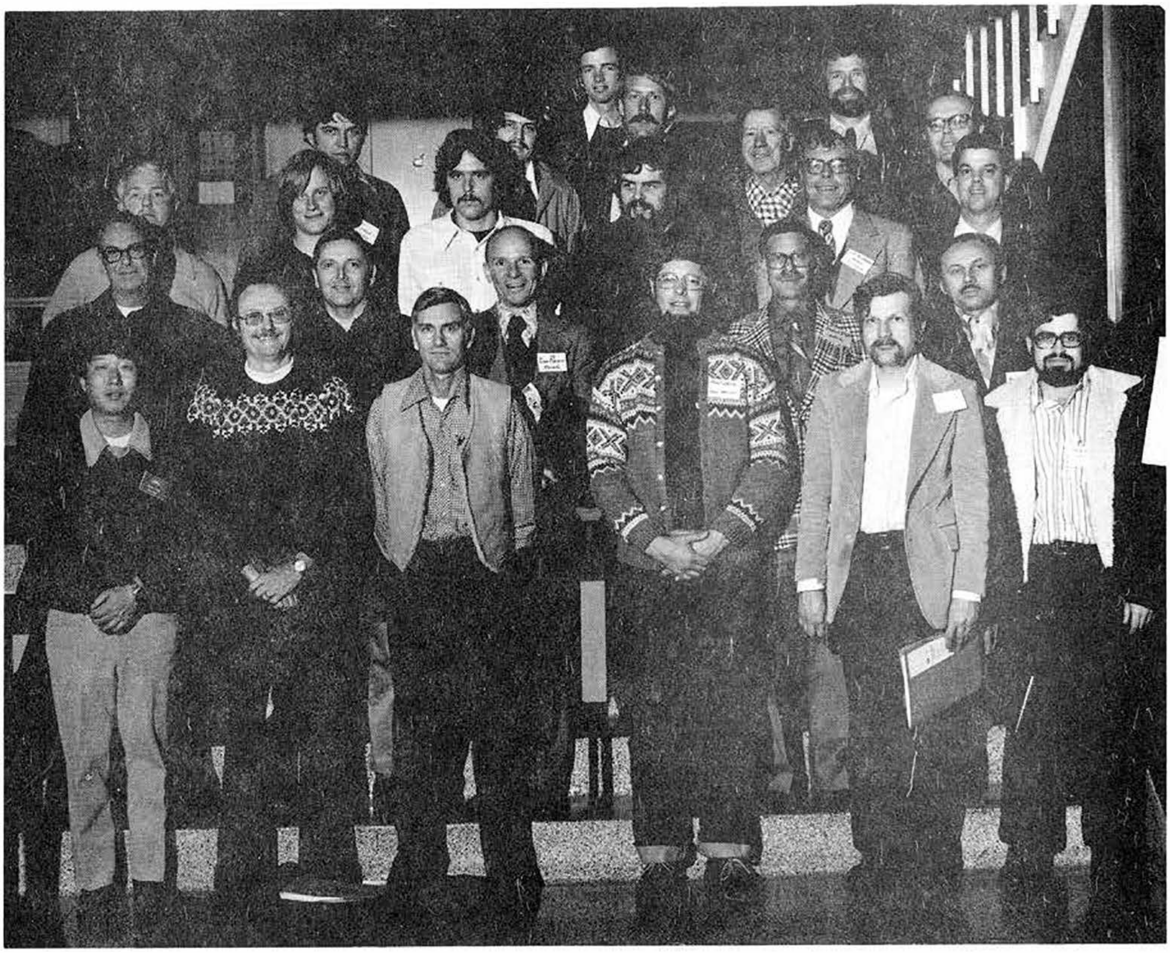

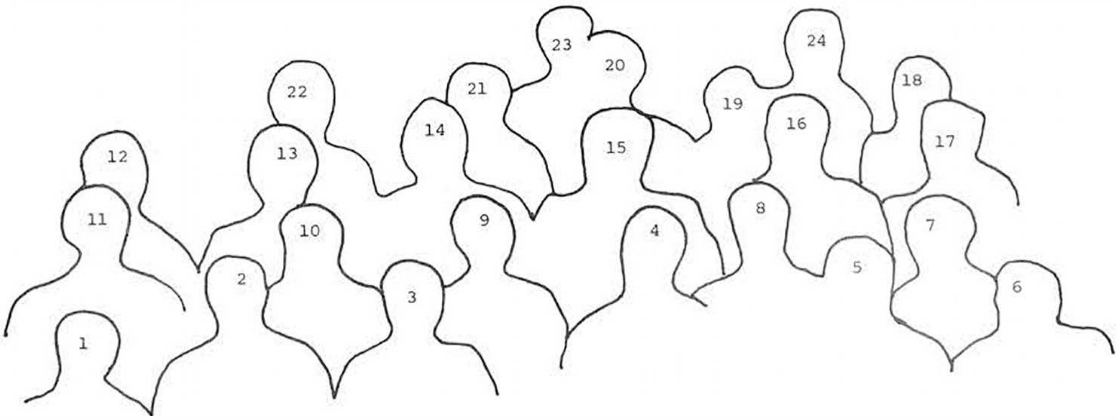

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6. Mark Brown
7. V. Korelus
8. Howard Tripp
9. Donald Pierce
10. Harry Yates
11. Richard Hunt
12. Warren Webb
13. William Telfer
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16. Jim Kinghorn
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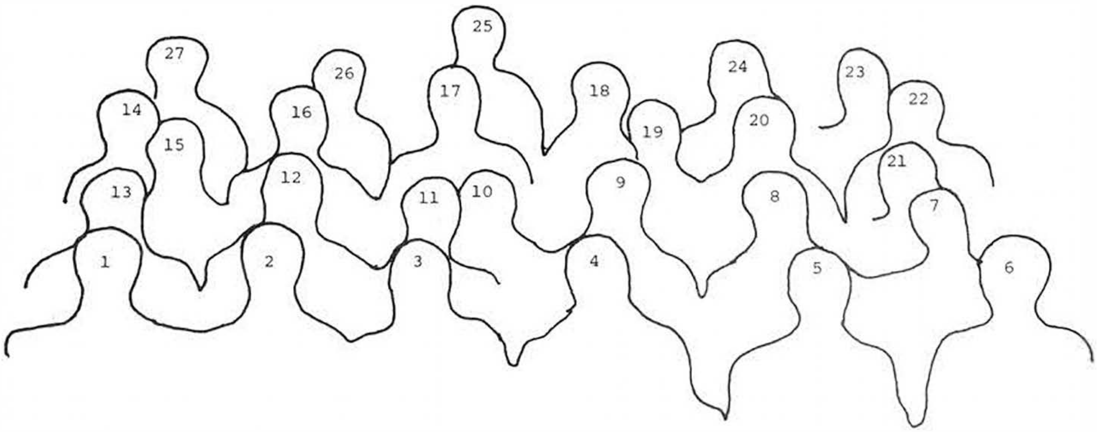

1. Bill Ives
2. Dave Parminter
3. Skeeter Werner
4. Paul Buffam
5. John Schenk
6. Bob Heller
7. Fred Honing
8. Mark McGregor
9. Fred Hain
10. David Kulhavy
11. Doug Parker
12. Bruce Hostetler
13. Vern Craig
14. Al Larsen
15. Alan Thomson
16. W. G. Evans
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18. Sue Watts
19. Ken Graham
20. Evan Nebeker
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24. Robert Luck
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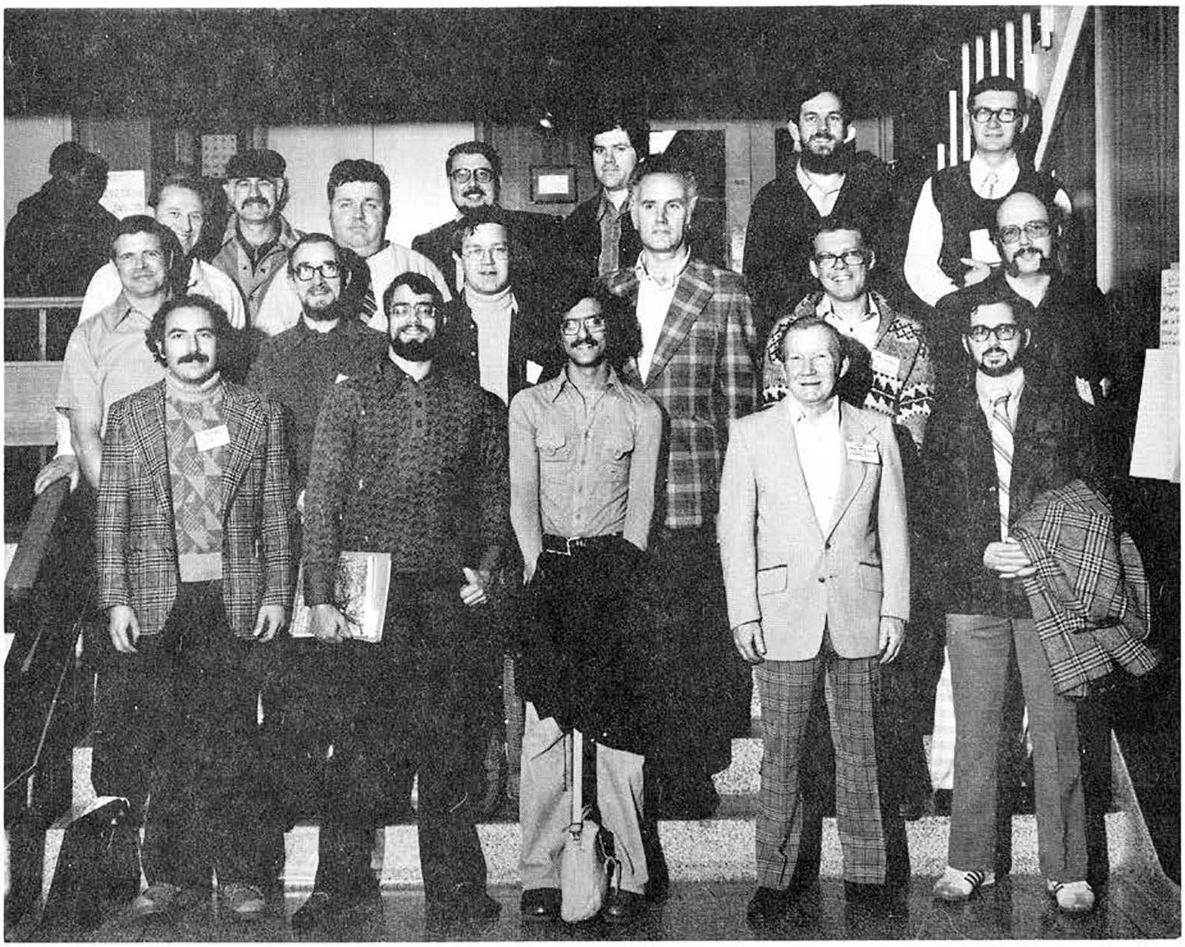

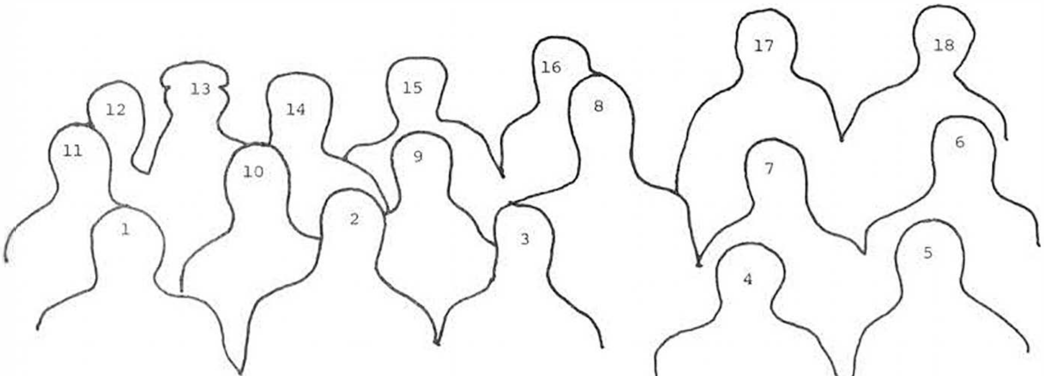

1. Rene' I. Alfaro
2. Shane Weber
3. Nasser Yalpani
4. Dave McComb
5. Lee Ryker
6. Gordon Miller
7. Lee Campbel
8. Carl Stozek
9. Ken Lewis
10. Stu Whitney
11. Jim Richerson
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13. Rick Johnsey
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15. Ross McDonald
16. Robert Hodgkinson
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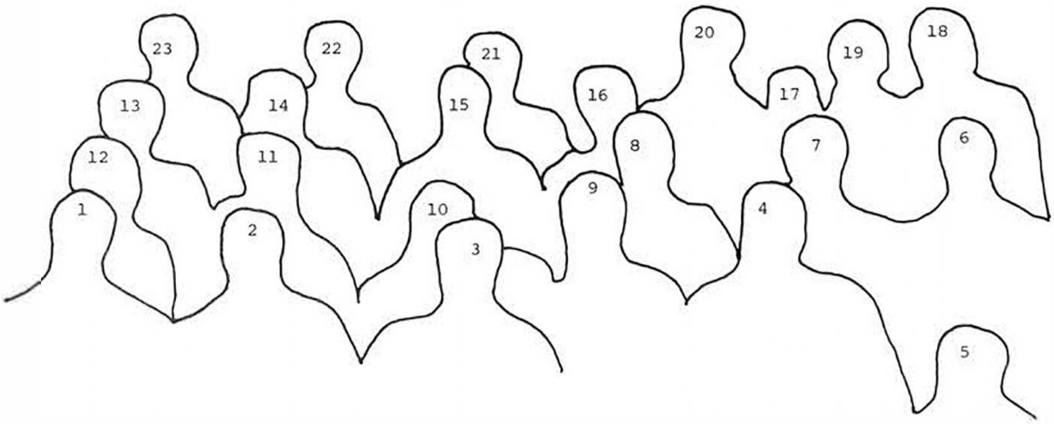
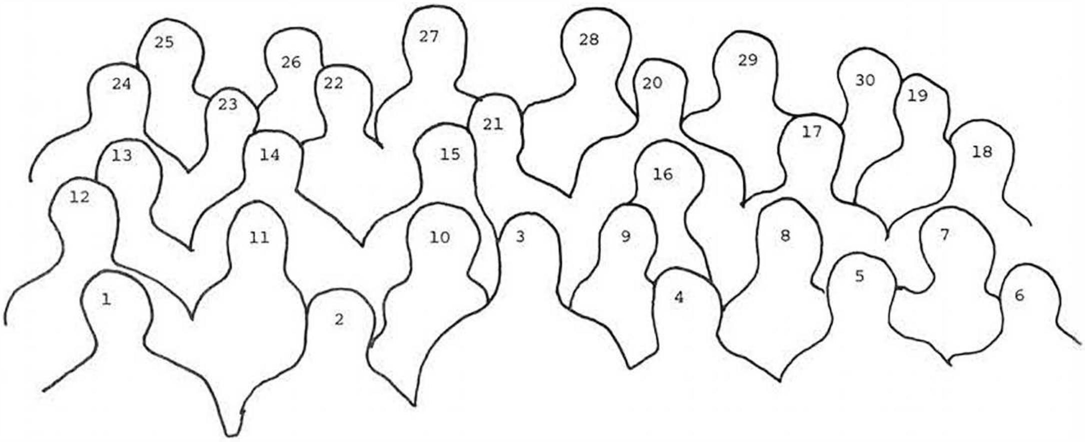


1. Ken Raffa
2. Charles Sartwell
3. Jim Lashomb
4. Tom Payne
5. Charles Minnemeyer
6. Jerry Knopf
7. Ken Lister
8. Ladd Livingston
9. Joe Elkinton
10. Mary Ellen Dix
11. Ronald Billings
12. Larry Yarger
13. Bob Stevens
14. Joe Pase
15. Jack Coster
16. Bill Thompson
17. Ed Hlady
18. Nick Crookston
19. Bob Monserud
20. Al Stage
21. Gary Daterman
22. Gary Boutz
23. Steve Cade



1. Paul Gravelle
2. Mike Atkins
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4. John Wenz
5. Fred Stephen
6. Clifford Ohmart
7. Jim Hansen
8. Jim Colbert
9. Ed Holsten
10. Don Dahlsten
11. M. W. Stock
12. Roy Hedden
13. Les McMullen
14. Al Rivas
15. Jerry Guenther
16. John Byers
17. Boyd Wickman
18. Jim Moore
19. Harold Osborn
20. Bob McKnight
21. Galen Trostle
22. George Ferrell
23. Roy Bennett
24. Max Ollieu
25. Doug Ross
26. Malcolm Shrimpton
27. Gary Pitman
28. William Cooper
29. David Voegtlin
30. Larry Wright

PROCEEDINGS

TWENTY-EIGHTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

Victoria, B. C.

March 1-3, 1977

Executive Committee (Twenty-eighth WFIWC)

R. L. Johnsey, Olympia	Chairman
G. C. Trostle, Portland	Immediate Past Chairman
L. N. Kline, Salem	Secretary-Treasurer
L. Safranyik, Victoria	Councilor (1974)
D. L. Parker, Albuquerque	Councilor (1975)
S. C. Cade, Hot Springs	Councilor (1976)
D. M. Shrimpton, Victoria	Program Chairman

CONTENTS

*Summary not submitted

TECHNICAL PROGRAM

Twenty-eighth Annual Western Forest Insect Work Conference

Empress Hotel, Victoria, British Columbia

March 1-3, 1977.

Monday, February 28

7:00 - 9:00 p.m.	Early Registration
8:00 p.m. Boardroom	Meeting of the Executive Committee

Tuesday, March 1

8:00 a.m.	Registration	
8:30 - 9:00 a.m. Georgian Lounge	Welcome and initial business meeting	
9:00 - 12:00 noon Georgian Lounge	PANEL: Impact of defoliation and its measurement Moderator:	B. Wickman
	A. Using aerial photography to sample short and long term tree damage	J. Wear
	B. Methods and problems in estimating defoliation.	G. Trostle
10:00 a.m.	Coffee break	
	C. Relating insect numbers and defoliation.	B. Wickman
	D. Impact of defoliation upon the food resources of the trees.	W. Webb
	E. Impact of defoliation upon the forest and the trees.	A. Van Sickle
	F. Relation between defoliation and bark beetle attacks.	L. McMullen
12:00 - 1:30 p.m.	Lunch	

1:30 - 2:30 p.m.

G. Modelling defoliation and tree damage. — J. Colbert

H. Discussion, summary and recommendations.

Panel and audience.

2:30 - 5:00 p.m. — WORKSHOPS: Who is doing what in forest entomology. The plan is to explore the current entomological activities of the membership.

A. Bark beetles: surveys and applied control. — M. McGregor

B. Bark beetles: research. — J. Coster

C. Defoliators: surveys and applied control. — F. Honing

D. Defoliators: research. — G. Daterman

E. Insects of nurseries and immature forests. — C. Sartwell

F. Seed orchard insect problems. — S. Cade

6:15 p.m. — Bus leaves the "Porte Cochere" at Empress Hotel for Banquet at Princess Mary, return 9:30 p.m. to the Hotel.

Wednesday, March 2

8:30 - 11:30 a.m.
Georgian Lounge — PANEL: Insect dispersal.
Moderator: W. Wellington

A. Genetic markers for identification of insect populations. — M. Stock

B. Studies of dispersal through X-ray identification of trace elements. — R. Bennet

Coffee break

C. Treatment and consequences of dispersal in some insect population models. W. Thompson

D. Dispersal in relation to weather in rough terrain. W. Wellington

11:30 - 1:00 p.m. Lunch

1:00 p.m. Bus leaves the "Porte Cochere" for the Pacific Forest Research Centre.

1:30 - 3:30 p.m.
Pacific Forest
Research Centre

WORKSHOPS:

A. Host reaction to stem attacks by insects. M. Shrimpton

B. Host recognition by insects. T. Payne

C. Development of biological control techniques in forest entomology. K. Graham

D. Computer analysis of historical forest insect survey data. J. Harris

E. Demonstration of simulation models of forest insect - stand interaction. A. Thomson

3:30 p.m. Bus leaves the Pacific Forest Research Centre for the Oak Bay Recreation Centre.

4:00 p.m. "The Bonspiel"

6:45 p.m. Bus returns to the Empress Hotel.

Thursday, March 3

8:30 - 9:00 a.m.
Georgian Lounge

Final business meeting.

9:00 - 12:00 noon
Georgian Lounge

PANEL: Pest impacts, an essential ingredient in Forest Management Planning.
Moderator: F. Honing

A. Eucosma impact on Klamath Tree Farm. — S. Cade

B. Douglas-fir tussock moth impact in N.E. Oregon. — G. Parsons

Coffee Break

C. Reduction of impact caused by mistletoe. — K. Russell

D. Reduction of insect impact through silvicultural practice. — K. Stoszek

E. Accounting for Pest losses in Management Plans. — A. Stage

12:00 - 1:30 p.m.	Lunch
1:30 - 4:30 p.m. Georgian Lounge	WORKSHOPS: Problem analysis and development of control strategy. Workshop coordinator: H. Tripp

Conference participants will be presented with background information on a current insect outbreak by the workshop coordinator. Following this, the participants will be divided into 5 groups and charged with the task of developing short- and long-term guidelines to manage affected stands. At the end, the groups will reassemble for a discussion of the guidelines that were developed in the 5 workshops.

1:30 - 1:45 p.m.	Introduction to the problem. — H. Tripp
1:45 - 3:15 p.m.	Group discussion.
3:15 p.m.	Beer Break.
3:30 - 4:15 p.m.	Summary of recommendations of each group.
4:15 - 4:30 p.m.	Concensus — H. Tripp

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WESTERN FOREST INSECT WORK CONFERENCE
Minutes of Executive Committee Meeting

February 28, 1977

Chairman Rick Johnsey called the meeting to order 36 minutes late (8:36 p.m.). Those present were:

Rick Johnsey
Galen Trostle
LeRoy Kline
Les Safranyik
Doug Parker
Steve Cade
Malcolm Shrimpton

Minutes of the 1976 Executive Committee meeting were read.

Registration fees were discussed. Motion passed that fees for this meeting be set at $12.50 for regular and $9.00 for student members.

Balance of funds to remain in the treasury was discussed. The Executive Committee recommended that a balance of approximately $500.00 be held in reserve. This matter was to be presented at the initial business meeting.

A means of reducing the cost of the meetings was suggested by LeRoy Kline. That was to eliminate from the proceedings the minutes of the Workshops and Panels. Everything else would be included. By doing this, costs could be reduced from about $2.50 per copy to about $0.75. It was moved to present this suggestion for discussion at the initial business meeting and a decision at the final business meeting.

There are a number of extra copies of proceedings from 1971 to 1976. Members wishing to receive these should contact Leroy Kline and pay a charge of $0.50 per copy.

The Executive Committee knew of no member being deceased during the past year. If the membership knows of anyone, please inform the secretary.

It was noted that a nominating committee should be appointed to make nominations to replace Les Safranyik whose term expires at this meeting.

It was suggested that a letter be sent to Rod Carrow to express appreciation for getting the 1977 program off to a good start.

Molly Stock, as chairperson of the Ethical Practice Committee, was charged with the responsibility to acquire (by any means possible) new and appropriate additions or replacements of accouterments, or what have you.

Since Galen Trostle was competing with Rick Johnsey in the telling of jokes, the meeting was adjourned at 9:15 p.m.

Minutes of the Initial Business Meeting

March 1, 1977

Chairman Rick Johnsey called the meeting to order at 8:40 a.m. He welcomed the members to Victoria and asked for introductions of new members.

Minutes of the 1976 final business meeting and the Treasurer's Report were read and approved. The treasurer reported a balance of $135.04 at the beginning of the 1977 meeting.

Minutes of the Executive Committee were read.

Malcolm Shrimpton reviewed this year's program.

Boyd Wickman reported for the Common Names Committee and stated that the Southwestern pine tip moth was being considered for Rhyacionia neomexicana by ESA.

Ken Lister reported that the 1978 meeting in Colorado will probably be at Durango and that Charles Minnemeyer will be the program chairman.

The meeting was adjourned at 9:00 a.m.

Treasurer's Report

February 28, 1977

Wemme, Oregon Meeting

Balance on hand March 1, 1976			$1,203.54
Received from registration	$1,154.00	(+)	2,357.54
Expenses for 1976 meeting	1,557.30	(-)	800.24
Received membership fee	45.00	(+)	845.24
Miscellaneous receipts	9.80	(+)	855.04
Preparation of proceedings	720.00	(-)	135.04
Balance on hand February 28, 1977			$ 135.04

PANEL: IMPACT OF DEFOLIATION AND ITS MEASUREMENT
Moderator: Boyd Wickman
Panelists: John Wear, Galen Trostle, Warren Webb, Allan Van Sickle, Les McMullen, Boyd Wickman, Jim Colbert

I am personally optimistic on this subject, but the fact remains that precise descriptions of impact caused by defoliating insects still elude us, even though investigators have been picking and prying at the problem over the past quarter century. I will spare you quotes from recent papers on pest management, integrated control, and the 1975 National Acedemy of Sciences report on "Forest Pest Control" because they all say the same thing. "Sound pest management hinges on good impact assessment and impact assessment seems to be the area in need of greatest improvement at this time." Now I get very upset over statements like this because tree damage caused by defoliating insects has been my bag for over 20 years. Where have I and others gone wrong?

Several things have happened--first, investigations have been intermittent because funds have been available only after large outbreaks and even then they have been pittances. Second, there is always great concern over developing and applying an insecticide to stop the damage but little interest by forest managers in long-term studies on the "net impacts." It seems to be a truism that we are usually fire fighters not entomologists. And finally, I don't think that we have had the tools to properly analyze, integrate, and digest the huge amounts of data we collect on defoliator populations, tree damage, control results, etc. after every outbreak.

I see two developments that have changed much of this. First, well-funded research and development programs which have allowed us to continue our research well past the mop-up stage, and most important, the advent of computer science and systems analysis. There are probably as many opinions about models as there are entomologists in this room, but for better or worse they are imposing a new tradition of multidisciplinary research, are giving us new insights into data needs, and they give us a method of integrating complex biological relationships.

In other words, we forest entomologists finally have the opportunity to come up with solutions for vexing problems like impact assessment with the help of tree physiologists, ecologists, mathematicians, and systems analysts.

Sequential Color Infrared Photography to Measure Defoliator Impact:
John Wear, USDA-FS, R-6, Portland, Oregon

Although color and color infrared photography have been used at various scales to evaluate the effects of forest insect activity, the Douglas-fir Tussock Moth Impact Survey initiated by R-6 FIDM in 1973, evaluates the short- and long-range effects of major defoliators. Sequential photography taken each year (from the outbreak start) monitors the intensities with a high degree of accuracy.

Multi-stage and double-sampling techniques with stratification provide a more accurate, faster and less costly impact survey than can be obtained from a ground survey of equal accuracy. The sequential photography provides a permanent sample that enhances photo interpreters confidence and reduces omission and comission errors.

The actual impact on volume losses of the forest resource require accurate ground data collection on a relatively few plots compared with the large photo sample. Statistical and computer programs are readily available for processing defoliation impact data. Quality control on all phases of impact surveys is essential (photography, field plot checking, and photo interpretation).

A properly implemented multi-stage or double-sampling impact survey provides the forester or land manager with useful information to make decisions on:

1. Need for defoliator control actions to reduce adverse impact after a specific length of time.

2. Need for initiating salvage operations.

3. Need for adjusting short-range and long-range management plans for stand, or compartment composition to reduce potential impact on both overstory and understory vegetation.

The photography survey tools are currently available in films, cameras, aircraft, and photo techniques to provide the land manager with excellent impact data if he can obtain high quality trained personnel to implement the survey.

Methods and Problems in Estimating Defoliation: Galen Trostle, USDA-FS, R-6, Portland, Oregon

We measure defoliation at several levels: (1) stand, (2) tree crowns, (3) branch, and (4) needles.

Stand defoliation. Used in aerial observations.

A. Contiguous area of defoliation such as: Light - Medium - Heavy - Very heavy (total).

B. Classification of areas as:

1. 50% of stand > 50% defoliated

2. 50% of stand - 25% to 50% defoliated

3. 50% of stand current foliage < 25% defoliated

4. no defoliation

Problem: The danger from this classification comes from looking at many individuals as one class and is often based on appearance rather that actual measure. A windstorm can change a stand that was classed as heavy to one that is classed as light.

Defoliation of tree crowns.

A. Total amount of crown defoliated by sixth or fourths or thirds.

B. Amount of defoliation compared to total amount of foliage on tree, expressed as percent of total defoliated.

Problem: Amount of defoliation when measured as total defoliation does not indicate the amount of crown or foliage remaining. A crown to height ratio of 0.5 defoliated 3/6 is not nearly as serious as is the same 3/6 defoliation on a tree with a crown ratio of 0.1. The age of the tree is significant as well. Ten-year-old regeneration defoliated 2/3 will probably die, yet many of you have seen refloiation in 80-year-old trees defoliated to the same degree.

It is extremely difficult and time-consuming to make accurate estimates of total foliage mass of a given tree and even if it is made very accurately we have no way to relate it to tree damage.

Branch defoliation. Often used to assess comparative damage between areas. Examples are:

A. Percent defoliation

B. Current foliage vs. old foliage

C. Class defoliation (light, medium, heavy)

Problem: Branch sample is difficult to relate to damage to tree and to insect population levels--depends on where branch is taken, outer branch or inner branch, upper or lower crown, etc.

Needle defoliation. Usually used to assess benefits of treatments to reduce populations.

A. Number of needles damaged vs. total

B. Class of damage levels

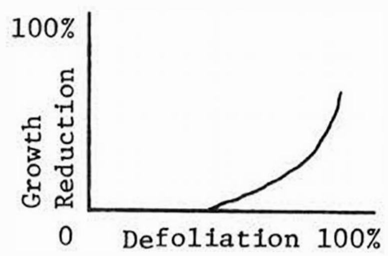
C. Bud damage

Problem: No relationship between population level and damage or predicted damage from sampled populations. Not related to tree or stand damage.

There are two general problems associated with most of our methods of defoliation measurements.

1. No system has been developed which related defoliation both to population levels and to tree or stand impacts.

2. Most of our systems give equal weight to each class of defoliation where as it is well known that impact is the result of accumulated defoliation on a curvilinear scale.



Effect of Defoliation by the DFTM on Reserve Energy of Douglas-fir: Warren L. Webb, Forestry Department, Oregon State University, Corvallis, Oregon

The starch content of Douglas-fir was substantially reduced following defoliation by the tussock moth. The remaining needles, twigs and roots all showed a linear reduction with increased defoliation as measured at bud burst in May. Further, the starch content of partially defoliated trees declined to near zero in midsummer while healthy trees retained some starch until late fall. Preliminary data show a relation between starch content and crown regrowth following cessation of defoliation.

Impact of Defoliation on the Forest and the Tree: Allan Van Sickle, Pacific Forest Research Centre, Victoria, B.C.

Detailed damage appraisal plots have been maintained to record defoliation, recovery, and mortality from several defoliators active since 1970. Once stands recover, representative trees will be felled and analysed to quantify radial, height and volume losses.

In 1976 several prism cruises were run in semi-mature Douglas-fir stands with a history of infestations. Tree mortality from recent budworm activity averaged less than 1% in 16 of 20 stands, but reached 32% in part of one stand and 4 to 6% in three others. Bark beetles were generally absent except in two stands where previous attacks combined with the defoliation by budworm caused an additional 9 to 11% mortality, and current attacks will add to the loss in 1977. Current top-killing on 10 to 77% of the trees, and averaging 0.7 to 4 m in length, was evident in 13 stands.

Cruises in four stands defoliated by the false hemlock looper for 2 years indicated 6% mortality, and 1 to 2 m of top-kill on 8 to 22% of the trees.

Detailed study of Douglas-fir branches during 2 years' severe budworm defoliation, 1 year moderate, and 2 years recovery indicate a substantial decrease in internode numbers (7.9 per branch before vs less than one during outbreak) and length (1.8 vs 0.5 inches); an increase to 88% in foliage produced adventitiously; and dieback increasing until by 1975, 19% of the internodes produced since 1967 had died.

Relation Between Defoliation and Bark Beetle Attacks: Les McMullen, Pacific Forest Research Centre, Victoria, B.C.

The probability of bark beetle infestation following defoliation by other insects is an important consideration in designing strategy to control damage. Although defoliation alone may cause growth reduction, die-back, and mortality, damage caused by subsequent bark beetle infestation may be even more severe. Little is known about the relationship between defoliation and subsequent bark beetle attack, but bark beetles have been implicated following defoliation by several insects. The role of the defoliators as a predisposing agent for bark beetle attack appears to vary with species.

Mortality of white spruce associated with bark beetle attack following defoliation by spruce budworm was described by Thomas (1958). McKnight (1968) in discussing western spruce budworm states "It is more than likely that the weakening effect of defoliation makes the host trees more susceptible to bark beetle attack. Apparently the point has never been tested, and therefore neither proven nor disproven."

Fifty-four percent of mortality following defoliation of ponderosa pine by pine butterfly was associated with western pine beetle (Evenden 1940). Mortality was associated only with the most severely defoliated trees and that due to defoliation alone continued for 8 years after peak defoliation, whereas that associated with western pine beetle was almost complete after 5 years. Such differences suggest that the beetle was simply taking advantage of the weakened trees and was really causing little extra mortality. Engraver beetle attack was related to degree of defoliation by a pine looper (*Phaeoura mexicanaria*) on ponderosa pine (Dewey *et al*. 1974). Bark beetles attacked 75 percent of the most severely defoliated trees, whereas only 3 percent of partially defoliated trees were attacked by the beetles. Beetle activity declined one year following the defoliation.

Over 75 percent of the mortality which occurred following defoliation of white fir by Douglas-fir tussock moth was associated with damage by other insects, the fir engraver and the round-headed fir borer (Wickman 1958, 1963). Fir engraver attack was consistently associated with periods of Douglas-fir tussock moth defoliation in grand fir (Berryman 1973). Wickman (personal communication) records that mortality following Douglas-fir tussock moth defoliation on grand fir associated with bark beetle attack was related to degree of defoliation. Such mortality was distributed fairly evenly through the 75 to 100 percent defoliation categories with the highest level (7 percent) in the 90 percent category. He concludes that trees with over 90 percent defoliation have a high probability of dying whether bark beetles are present or not.

Mortality of Douglas-fir associated with Douglas-fir beetle attack following defoliation by Douglas-fir tussock moth was distributed between the 25 to 90 percent defoliation categories with the 90 percent category suffering the highest mortality (7 percent) (Wickman personal communication). The initial damage occurred primarily in the high defoliation categories and the most damage occurred the second year after defoliation started.

In British Columbia, the percent stems attacked by Douglas-fir beetle in 1976, the year following peak defoliation by the tussock moth, increased with severity of defoliation and with dbh. Attack occurred on 14 percent of all stems and on 21 percent of those with more than 80 percent defoliation. Trees over 40 cm dbh suffered 28 percent attack, while such trees with more than 80 percent defoliation suffered 48 percent attack. Attack density was low ($0.2/100\ cm^2$) and progeny density in October was high ($5.7/100\ cm^2$). Seventy-nine percent of the progeny had reached the young adult stage. Considering only the young adults these data represent an 11-fold population increase. Although defoliation on the trees examined for brood productivity was high, attack and progeny density and percent young adults was lower on trees with less than 90 percent defoliation.

Douglas-fir beetle attack was not consistently found associated with defoliation by western spruce budworm. The beetle was found in only 4 of 20 prism plot cruises in defoliated stands, and in only 2 of these were more than 0.5 percent of the stems attacked. In one of these two stands defoliation has been ongoing, whereas in the other, defoliation has been absent for the past two years. In the former, 32 percent of the stems are dead from defoliation alone, 11 percent from defoliation and beetle attack prior to 1976, and 11 percent were attacked by beetle in 1976. All beetle-attacked trees were severely defoliated and probably already dying. In the second stand comparable data are: 4 percent dead from defoliation along, 9 percent from defoliation and beetle attack prior to 1976, and 25 percent attacked by beetle in 1976. In a nearby plot (331 trees) trees dying from defoliation alone averaged 86 percent foliage loss, whereas those attacked by beetle averaged 53 percent defoliation. The beetles seem to be ignoring the severely defoliated trees and attacking those that might otherwise recover. In spite of the above apparent greater beetle success in the second site, brood productivity was about 50 percent of that in the first site. Overall brood productivity in budworm-defoliated Douglas-fir was much less than that in the tussock moth defoliation, with an indicated population increase of about one. Furthermore, the proportion of brood that had reached the young adult stage was only about 25 percent. It is also known that much of the attack occurred in late July, behavior not typical of Douglas-fir beetle.

The differences in Douglas-fir beetle attack and brood success between trees defoliated by Douglas-fir tussock moth and by budworm, albeit in rather different climatic areas, suggest considerable differences in the effect of defoliation on the trees. In fact the pattern of attack in budworm-defoliated stands appears to differ. These differences suggest that the bark beetle is posing a definite hazard to recovering and healthy trees in the tussock moth-defoliated area, whereas its role in the budworm defoliated areas is questionable. We suspect that the attack that we are aware of in the budworm defoliation may be coincidental but it needs close monitoring.

The observations in B.C. bear out the variation that appears to be associated with bark beetle damage following defoliation. Such apparent variation points out the need for an understanding of the effects of defoliation on the tree and an understanding of the reaction of bark beetles to those effects. The real importance of the bark beetles lie in their ability to utilize the weakened trees to build populations that can be damaging to recovering and healthy trees. Until an understanding of the above interactions is obtained the answer to the forest manager's question regarding the probability of mortality will remain highly speculative.

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Relating Insect Numbers and Defoliation: Boyd Wickman, USDA-FS, PNW, Corvallis, Oregon

A recent study relating Douglas-fir tussock moth larval populations with defoliation estimates was illustrated. Four levels of populations were sampled periodically through the larval feeding period. Foliage biomass was measured on population sample trees and ocular estimates of degree of defoliation were made for each sample tree. Larvae were also reared in the lab on host foliage to obtain consumption-destruction ratios for individual larval instars. Branch defoliation was then related to tree defoliation mathematically for use in the Douglas-fir tussock moth outbreak model.

Modeling Defoliation and Tree Damage: J. J. Colbert, Forestry Research Laboratory, Oregon State University, Corvallis, Oregon

Dr. W. Scott Overton and I have developed a model to simulate the dynamics of a Douglas-fir tussock moth outbreak, figure 1. The Stand Outbreak Model, as conceptualized, follows the insect/foliage dynamics of an outbreak through four years. As can be seen in figures 1 and 2, it is initialized by classifying the stand and outbreak properties. Upon termination of the outbreak, the resulting defoliation levels are translated into defoliation effects on the state variables of the normal stand model. As the title of the talk indicates, I am going to discuss the development of the defoliation effects model, figure 3.

There are five transfers or translations in the modeling of defoliation and tree damage as we have modeled it. The first is the feeding of the larvae and subsequent defoliation of the model branch. Second is the translation of the defoliation of the model branch into defoliation of the full crown of the tree. Following determination of the amount of tree defoliation we have a branching, from tree defoliation into direct mortality, that is, mortality as a direct result of tree defoliation, and from tree defoliation into prescribed levels of top-kill. Both of these are given as expectations associated with the classes of tree defoliation and levels of top-kill from the classification structures. The final transition is from top-kill class to secondary mortality. Again secondary mortality is expressed as an expectation and is derived from the conditional probabilities associated with prescribed levels of top-kill.

Direct mortality and top-kill are thus modeled as one-step markov processes and secondary mortality as a two-step markov process. However, the predictions are expressed as expectations, so that the conceptually stochastic model is used in a deterministic manner.

The most intensive and extended effort in the translation developments was the translation from model branch defoliation to tree defoliation, figure 4. When the modeling of the Douglas-fir tussock moth and its impact on foliage began, a model of the crown was developed. Foliage distribution and age structure were modeled explicitly over the full crown. The knowledge that the forest entomologists at the PNW, Corvallis, Forestry Sciences Laboratory had of the moths prefeeding establishment, dispersal, and feeding habits led to the current model branch conceptualization based on the midcrown sample design. First the horizontal uniformity of the insect distribution led to consideration of the variation in vertical distributions of foliage and insects, and their interaction. The vertical distribution and age structure of the foliage were modeled explicitly over the full crown. A hypothetical model of the distribution of defoliation over the crown resulted, figure 4a. From this the relation of model branch defoliation to percent of crown totally defoliated was developed, figure 4b.

The defoliation of the model branch is also used to develop impacts on tree growth. These effects are expressed as (1) a diameter growth factor and (2) a number of height growth factors and the associated probability of their occurrance. As of this date not all of the height and diameter data has been analyzed and consequently we expect some modification in the form of these two response functions as this data is analyzed.

The model output consists of two sets of tables. The first set is the Table 1 and Table 2 series. These give the annual resolution changes in the population and foliage (Table 1) and the defoliation summary and associated expected mortalities, top-kill, and growth losses (Table 2). The second set of tables gives the model parameterization (Table 3) for the particular simulation and the details of any of the state variables during the particular simulation (Table 4).

Figure Captions

Figure 1: The Douglas-fir tussock moth stand outbreak model: The conceptual structure of the stand outbreak model and its insertion in a normal forest model.

Figure 2: The coupling of a normal stand model and the stand outbreak model.

Figure 3: Defoliation effects model: Mortality and top-kill as they are derived from tree defoliation.

Figure 4: a) Hypothetical model of the distribution of defoliation over a tree at the end of an outbreak.

b) Tree defoliation as a function of defoliation of the model branch.

FIGURE 1

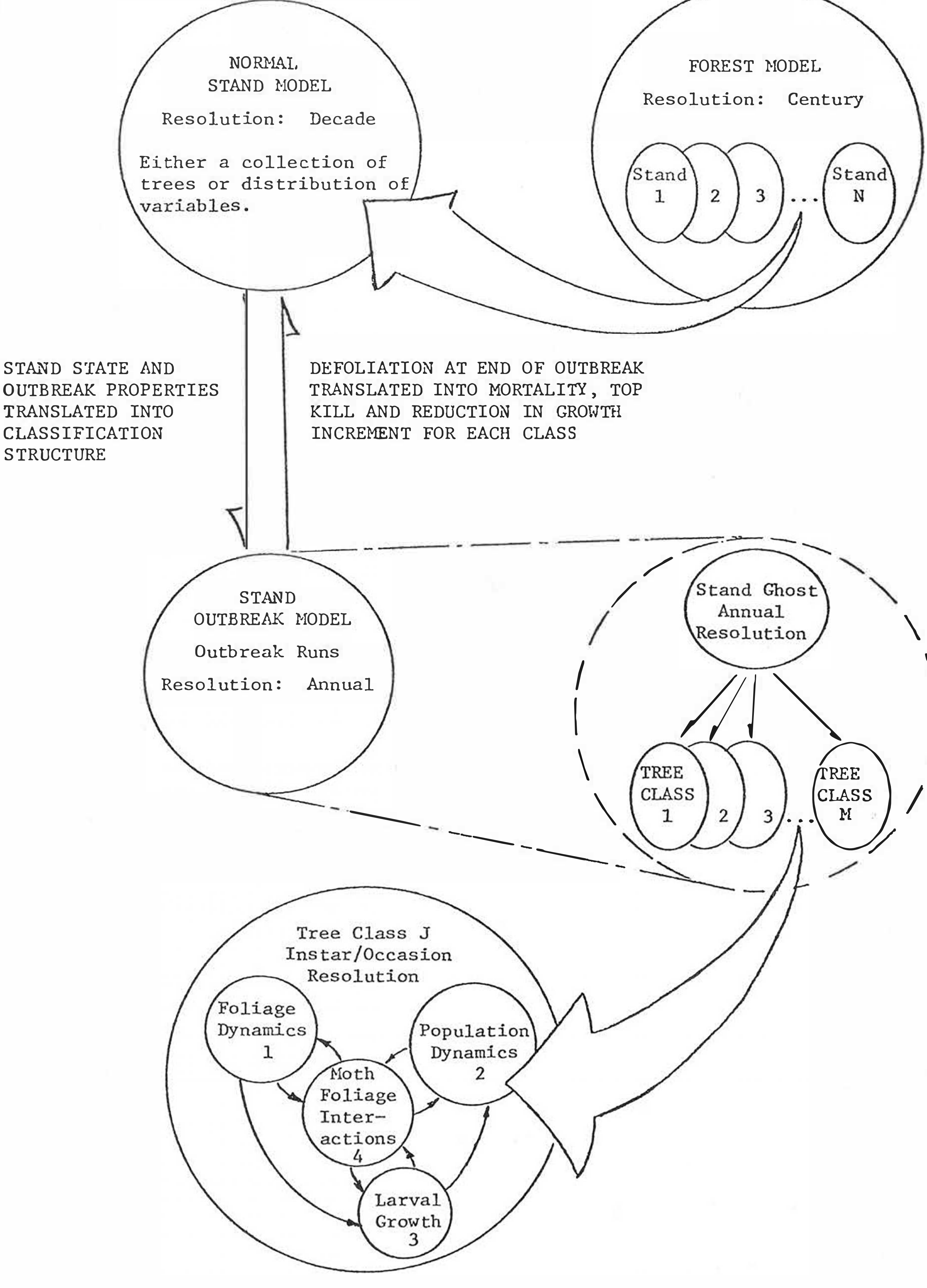

NORMAL
STAND MODEL
Resolution: Decade
Either a collection of trees or distribution of variables.
FOREST MODEL
Resolution: Century
Stand 1
2
3
...
Stand N
STAND STATE AND OUTBREAK PROPERTIES TRANSLATED INTO CLASSIFICATION STRUCTURE
DEFOLIATION AT END OF OUTBREAK TRANSLATED INTO MORTALITY, TOP KILL AND REDUCTION IN GROWTH INCREMENT FOR EACH CLASS
STAND
OUTBREAK MODEL
Outbreak Runs
Resolution: Annual
Stand Ghost
Annual
Resolution
TREE CLASS 1
2
3
...
TREE CLASS M
Tree Class J
Instar/Occasion
Resolution
Foliage Dynamics 1
Population Dynamics 2
Moth Foliage Inter-actions 4
Larval Growth 3

FIGURE 2

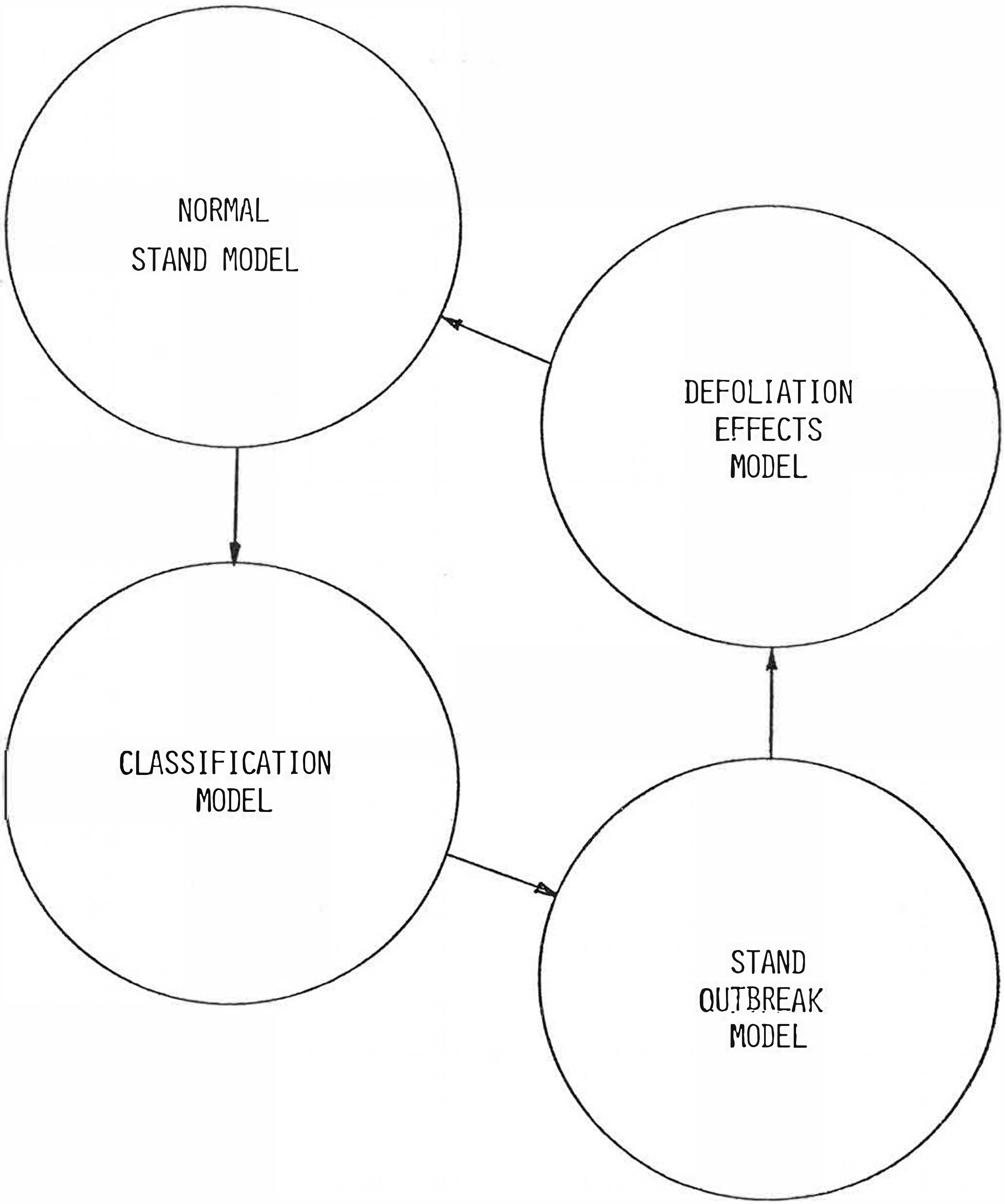

NORMAL
STAND MODEL
DEFOLIATION
EFFECTS
MODEL
CLASSIFICATION
MODEL
STAND
OUTBREAK
MODEL

FIGURE 3

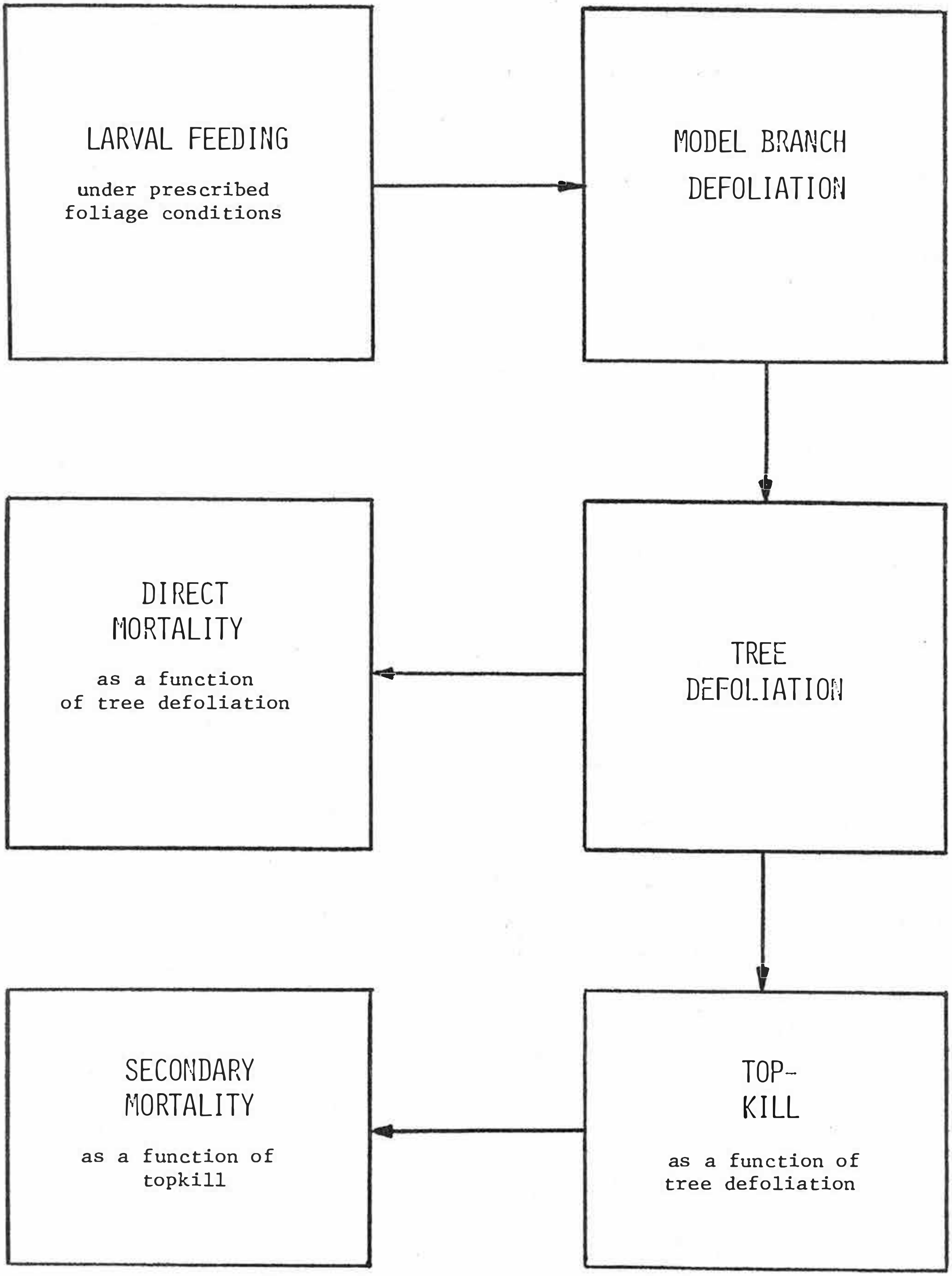

LARVAL FEEDING
under prescribed foliage conditions
MODEL BRANCH DEFOLIATION
TREE DEFOLIATION
DIRECT MORTALITY
as a function of tree defoliation
TOP-KILL
as a function of tree defoliation
SECONDARY MORTALITY
as a function of topkill

FIGURE 4a

Hypothetical Model of Distribution of Defoliation Over a Tree

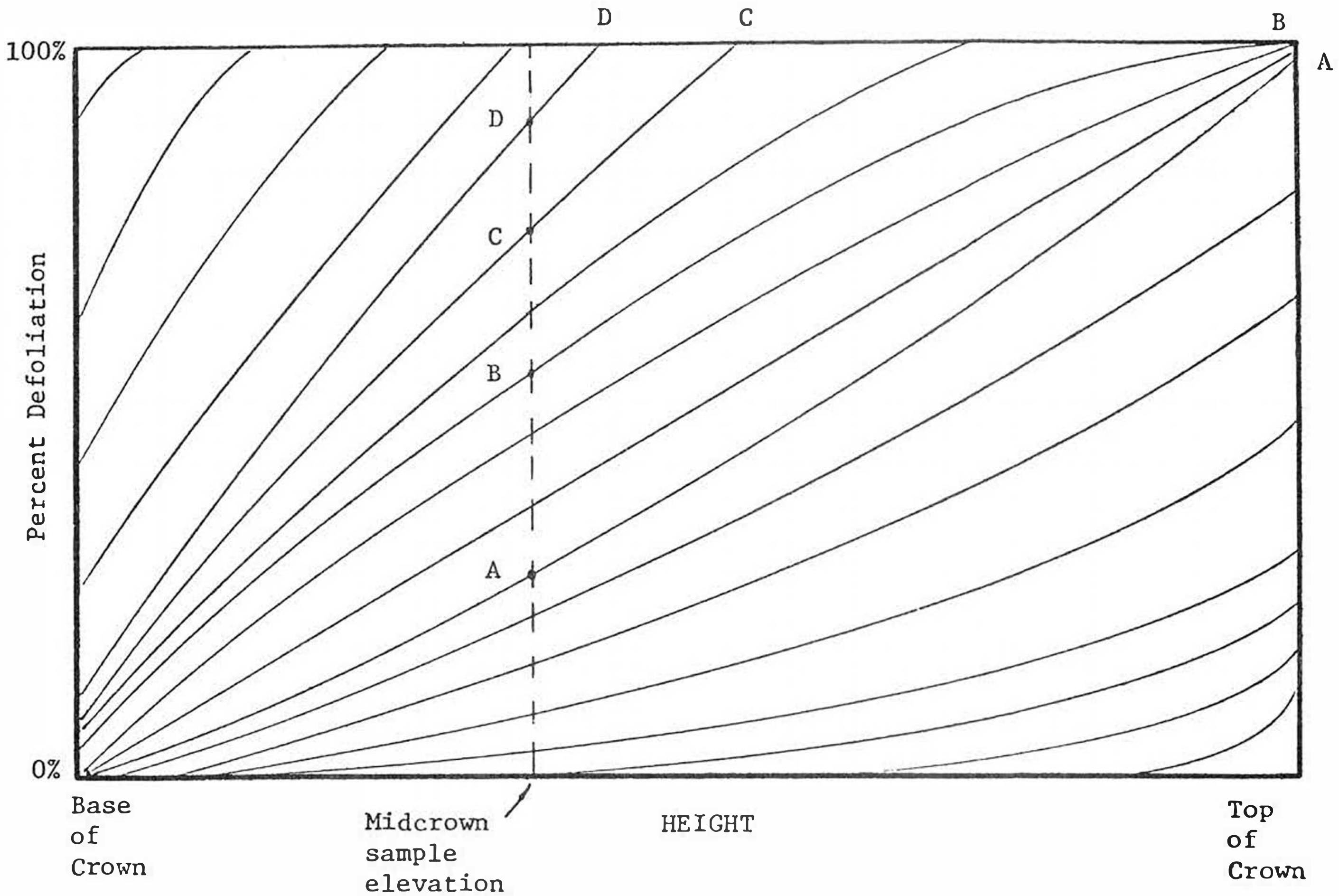
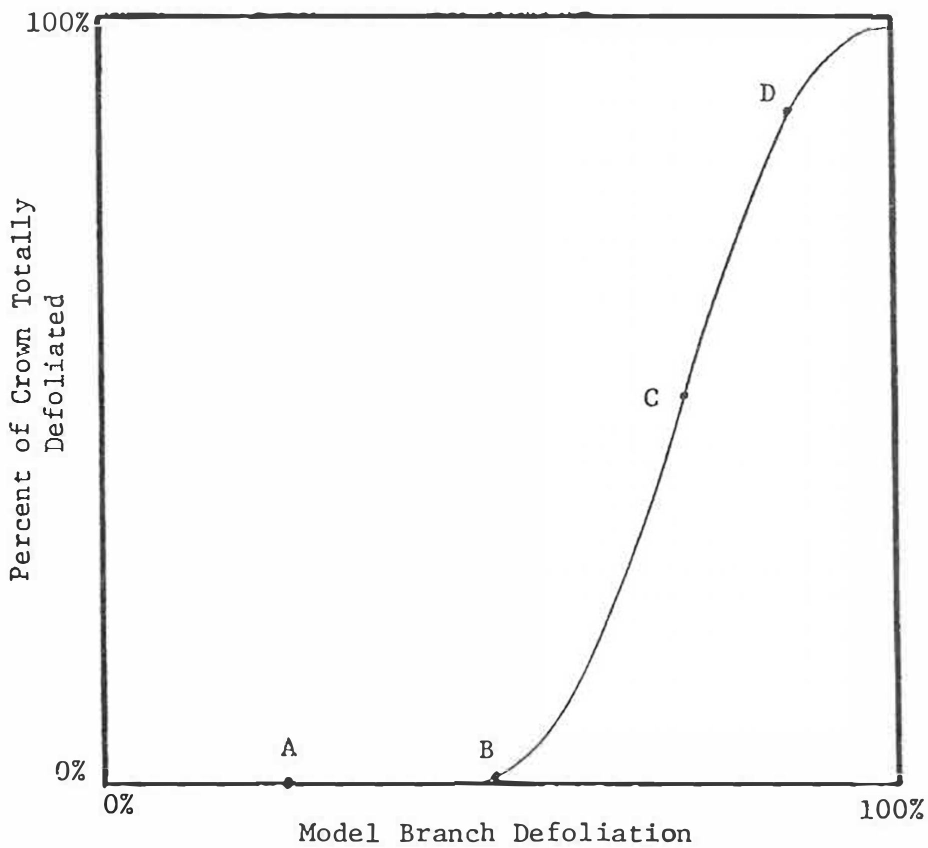


FIGURE 4b



Discussion and Recommendations

The panel and audience agreed that because of variation between different outbreaks and study results there was need for further research and application tests in the following areas.

1. Defoliation estimating.--Since percent defoliation is a common variable in many studies and is used for predicting tree damage by foresters, we should be improving the accuracy of our estimating techniques and trying to standardize them for various defoliators. This would allow us to directly compare results and provide better reliability of our estimates.

2. Bark beetle-defoliation relationships.--Bark beetle populations do not always develop in trees weakened by defoliation. We need to know more about what predisposes defoliated trees to attack by bark beetles. Such things as rootlet mortality, root diseases, and effect of other environmental factors are not well understood and must play an important role in this relationship. Tree physiologists should especially be involved in these investigations.

3. Tree growth reduction and its measurement.--It is known that tree defoliation reduces both radial and terminal growth, but the measurement of these variables is difficult and the interpretation of the data often open to question. Measurement techniques and instrumentation have out distanced our ability to interpret growth reduction in terms of stand growth over a rotation and the effects of competition and environmental influences on long-term growth. We need more assistance from mensurationists and silviculturists in this field and we particularly need good stand prognosis models for proper interpretation of data.

PANEL: INSECT DISPERSAL
Moderator: W.G. Wellington
Panelists: M.W. Stock, R.B. Bennett,
W.A. Thompson, W.G. Wellington

Four approaches to the problem of assessing or measuring insect dispersal were presented by the foregoing panelists on the morning of March 2. Dr. Stock described advances in techniques for identifying biochemical genetic markers, and gave background information on appropriate enzyme variants and electrophoretic techniques for those not familiar with the field. Dr. Bennet discussed the advantages of X-ray identification of trace elements in pin-pointing localities from which dispersing insects came. Dr. Thompson gave examples of simulation models that could be used to increase our knowledge of the process of dispersal. Dr. Wellington showed how the special kinds of clouds and air currents in mountainous terrain strongly and predictably influenced the trajectories as well as the amounts of dispersal in such areas. The detailed summaries follow.

GENETIC MARKERS FOR THE IDENTIFICATION OF INSECT POPULATIONS:
M.W. Stock, Entomology Department, University of Idaho, Moscow, ID 83843.

Newly developed techniques of biochemical genetic marking are proving valuable for studying and measuring insect dispersal. Enzyme variants, detected by electrophoretic separation of proteins, have many advantages over traditional types of "genetic" markers (e.g., morphotypes or behavioral variants) in that the latter are influenced by unknown numbers of genes and an unknown environmental component. By coupling starch gel electrophoresis with histochemical staining, we can rapidly assay gene products of at least 30 specific gene loci per insect, revealing homo- and heterozygous individuals for different variants. One person can obtain over 1200 units of genetic data on a sample of 50 insects in one day. In addition to its speed, this method of obtaining genetic data is also relatively simple and inexpensive.

Genetic markers occur naturally when populations differ sufficiently to be characterized by gene frequency differences for various protein variants. The potential value of a biochemical genetic marker for identifying populations increases as the differences in its frequency increase between populations. By artifical propagation, fixation for a rare protein isomer can be created in a straightforward and rapid manner, and used to produce marked stock for dispersal studies. In essence, we maximize the genetic difference

at a single locus between the marked and the natural populations. The procedure involves selecting parental types with two doses of a variant gene (i.e., homozygous for a rare allele). Within one or two generations, sufficient individuals of both sexes homozygous for that rare variant can arise to mark the laboratory population. Potential pitfalls include inbreeding and differential selection, but both can be minimized by appropriate precautions in testing.

Applications of genetically marked stock to assess insect dispersal are many and diverse. The method is being used successfully in mark-recapture studies, and it can also be used to evaluate migration patterns and the distances traveled by individuals in low-density and epidemic populations.

YOU ARE WHERE YOU EAT: R.B. Bennett, Bennet Analytical X-Ray Ltd., 1908 Mahon Avenue, North Vancouver, B.C., Canada, V7M 2T5.

Most control studies on insect dispersal and population dynamics are hindered by the fact that insects are extremely difficult to follow in the field. Mark-release methods involve toxicological and behavioral problems which can affect natural dispersion. All of these problems can be avoided by using chemical "fingerprinting" of larval habitats with X-Ray Energy-dispersive Spectroscopy (XES). Each habitat is elementally unique at concentrations of one part per million for the range of elements from sodium to uranium. Larvae do their incorporation in one particular habitat, and when adults fly off they are still uniquely marked from that larval habitat. Thus large re-captures are not necessary to determine population dynamics. Samples of larvae are collected from various sources and typed, migrant adults are then analyzed and related to the various larval sources. A discriminate analysis is used to handle the data and, by setting the thresholds of discrimination, populations close or far apart can be determined. The method has been applied to pest Lepidoptera, Aphididae, Coleoptera and Diptera from both tracheal and larval habitats. Larval populations from unknown as well as from known sources can be determined. The technique should give a new dimension to control strategies involving forest insect pests.

TREATMENT AND CONSEQUENCES OF DISPERSAL IN SOME INSECT POPULATION MODELS: W.A. Thompson, Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C., Canada, V6T 1W5.

Ecologists often face the problem that data on the dispersal of individual organisms in a given population are scarce and

unreliable. However, by constructing a simulation model based upon data gathered at the individual level within such populations, one can make predictions regarding the dispersal process at the population level. In some cases, the predictions fail to match observation, thus indicating an inadequate knowledge of dispersal at the organismal level. Additional simulation experiments may then help to distinguish between the need for more (or more reliable) data of the type already gathered, and the need to investigate additional factors influencing dispersal behavior. In contrast, whenever the simulation model successfully predicts dispersal phenomena at the population level, the model can be regarded as an hypothesis. Additional simulation experiments then can be developed to identify required critical laboratory or field experiments.

This approach was illustrated by a specific example drawn from a model of the western tent caterpillar (Malacosoma californicum pluviale (Dyar)). This model has performed well in predicting population phenomena from individual behavior, and simulation experiments have also shown the value of studying "refuge" size. When field experiments suggested by the modeling results were carried out on a series of small islands, populations with vastly different dispersal behavior were discovered. Experiments attempting to link the dispersal of their adults to larval diet have proved illuminating and are being pursued further.

DISPERSAL IN RELATION TO WEATHER IN ROUGH TERRAIN: W.G. Wellington, Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C., V6T 1W5.

Data from synoptic meteorology, weather satellites and radar all show that there is more than a simple relationship with wind speed involved in the linkage of large-scale movements of insects or plant pathogens with large-scale weather systems. The key to the more complex relationship appears to be the mesoscale weather induced by the terrain over which the large fronts and air masses travel. In mountains, especially, terrain-induced weather significantly affects the direction as well as the timing and the amount of any dispersal.

Mountains severely reduce the dispersive capacity of frontal systems by confining warm-frontal turbulence to the less inhabited upper slopes above valley bottom, and by channeling cold-frontal turbulent transport through a few major passes and valleys. Frontal dispersal in mountainous terrain therefore is less a matter of long-range transport than of shorter-range movements along or across particular valleys.

Between frontal passages, the daily cycle of solar heating produces very regular and predictable circulation patterns that provide reliable transportation for small larvae and other wingless flotsam within a valley. Active fliers, however, are affected differently than drifting insects by these patterned air currents, because their navigation by polarized sky-light is disrupted by the patches of clouds regularly associated with the areas of upwelling in the patterns. The flights of diurnally dispersing insects thus are directed away from the cloudy patches and channeled through the intervening clear zones. Host- and mate-finding territorial behavior, and selection of home ranges all may be drastically affected by such channeling. The influence of terrain-induced air currents and cloudiness on the patterns of distribution of immature and adult insects in the mountains therefore must not be discounted in sampling or control programs.

Panel: Pest Impacts, an Essentail Ingredient in Forest Management Planning

(Only the following paper of the panel by Glenn Parsons on "Douglas-fir Tussock Moth Impact in N.E. Oregon" was submitted.)

8D-3078

28TH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

EMPRESS HOTEL
VICTORIA, BRITISH COLUMBIA
MARCH 1 - 3, 1977

BY
GLENN B. PARSONS, CHIEF FORESTER
BOISE CASCADE CORPORATION
NORTHEAST OREGON REGION
LA GRANDE, OREGON

THANK YOU FOR GIVING ME THE OPPORTUNITY TO PARTICIPATE IN THE 20TH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE. AS YOU KNOW, THERE IS A VERY SERIOUS FOREST INSECT PROBLEM IN THIS NATION AND IN THE BLUE MOUNTAINS IN NORTHEAST OREGON AND SOUTHEAST WASHINGTON. THE PUBLIC AND PRIVATE TIMBERLAND OWNERS ARE GREATLY CONCERNED WITH THIS PROBLEM.

DOUGLAS-FIR TUSSOCK MOTH IMPACTS IN NORTHEAST OREGON

YOUR PANEL MODERATOR SUGGESTED THAT I DISCUSS THE DOUGLAS-FIR TUSSOCK MOTH IMPACTS ON PRIVATE FORESTS IN NORTHEAST OREGON. TO FULFILL MY ASSIGNED ROLE, WE NEED TO DIGRESS TWO DECADES TO PREPARE A MENTAL NOTE OF BOISE CASCADE'S BLUE MOUNTAIN TREE FARM. THEN WE WILL PLACE THIS MODEL IN PERSPECTIVE WITH THE MAJOR MANAGEMENT PROBLEMS THAT OCCURRED DURING THIS DEVELOPMENT PERIOD, REVIEW BOISE CASCADE'S TIMBER MANAGEMENT OBJECTIVES AND, FINALLY, PRESENT YOU WITH A PROPOSAL TO HELP MINIMIZE OUR GREATEST FORESTRY PROBLEM . . . ACCELERATE MANAGEMENT OF FOREST INSECTS.

THE FOREST MODEL

WE ARE AN INFANT WHEN COMPARED TIMEWISE TO OTHER FOREST PRODUCTS COMPANIES. BOISE CASCADE WAS FORMED IN 1957 THROUGH THE CONSOLIDATION OF BOISE PAYETTE LUMBER COMPANY IN SOUTHERN IDAHO AND CASCADE LUMBER COMPANY IN EASTERN WASHINGTON, WHICH WAS FOLLOWED BY THE 1959 MERGER OF VALSETZ LUMBER COMPANY IN OREGON, TO COMPLETE THE THREE-STATE FOREST PRODUCTS TRIANGLE.

Our Northeast Oregon tree farm started from a 20,000-acre "nest egg" which has now grown to over 300,000 acres. Our first management concerns were to obtain a forest land base to insure the development of an integrated operation which is essential in today's competitive wood fiber market. This land base was purchased from many small, private woodland owners and from several timber companies. Our tree farm is located in five Northeast Oregon counties. . . Wallowa, Union, Baker, Umatilla and Morrow; and in three Southeast Washington counties . . . Walla Walla, Columbia and Garfield. Our primary objective was to obtain forest properties with good stocking of commercial tree species located in areas with the desired forest soils and moisture conditions. We recognized the significance of the deep volcanic ash soils (Tolo) in the Northern Blue Mountains located in the center of the major storm paths. The more moist forest soils contain the Upper Slope Mixture of grand fir, Douglas-fir, western larch, and Engelmann spruce. The drier sites contain a ponderosa pine mixture.

OUR TIMBER MANAGEMENT OBJECTIVES AND POLICIES

Timberlands are Boise Cascade's most valuable resources. These lands help maintain full production in our various processing plants; maintain a strong labor market; maintain a complete forest product-mix for the national and world market place; and maintain a strong and healthy economic environment in the many local dependent communities.

Because of increasing competition for the land base made necessary by our rapidly expanding population, we made a critical analysis of our regional timberlands. This analysis considered the private land base necessary to produce the wood fiber needed to sustain our existing and planned manufacturing plant facilities; and it considered all economically feasible management techniques for improving the productivity of our tree farms.

It is our policy to manage our Northeast Oregon tree farm on a multiple-use, sustained yield basis in a manner to obtain the greatest long range benefits to the corporation and dependent communities.

As guidelines to improve our land management practices we have adopted the philosophy to maximize utilization of our forest resources and to increase productivity of our forest property to its greatest potential.

Douglas-Fir Tussock Moth Dilemma

These goals were developed in 1968 and we were well on our way toward achieving them. Eastern Oregon's first plywood plant was constructed in 1964 to give us a better product mix to help meet the national home building standards of 2.6 million annual housing starts; a particleboard plant was constructed to better utilize the dry mill waste for the industrial market; our chipping facilities were improved to help meet national paper products goals; and the conversion capabilities of our studmill and sawmills were improved. The wholly integrated capabilities of our Northeast Oregon Region were designed for maximum realization and

UTILIZATION OF AVAILABLE TIMBER AT MINIMUM COSTS WITH ENVIRONMENTALLY ACCEPTABLE STANDARDS.

OUR TIMBER HARVESTING CAPABILITIES WERE IMPROVED AS RAPIDLY AS MODERN TECHNOLOGY COULD DEVELOP THE NECESSARY MACHINES TO PROPERLY UTILIZE OUR CHANGING FORESTS. OUR FOREST MANAGEMENT PRACTICES WERE BEING ACCELERATED TO ACHIEVE OUR GOAL OF HAVING OUR TIMBERLANDS FULLY STOCKED WITH YOUNG, VIGOROUS TREES BY 1990.

THEN, THE DOUGLAS-FIR TUSSOCK MOTH RAVAGED THE BLUE MOUNTAIN FORESTS IN 1972 AND 1973. TODAY WE ARE FURTHER FROM ACHIEVING THESE GOALS THAN WHEN THIS PROGRAM WAS INITIATED.

WE ARE IN THE "DECADE OF FOREST INSECTS". THIS CONDITION EXISTS NOT ONLY IN THE BLUE MOUNTAINS, BUT GENERALLY THROUGHOUT THE WEST AND IN MANY OTHER MAJOR GEOGRAPHIC AREAS OF THIS COUNTRY.

FOUR YEARS AGO, THE BLUE MOUNTAIN FORESTS HELPED MAKE HISTORY WITH ITS APPROXIMATE 600,000 ACRE DOUGLAS-FIR TUSSOCK MOTH EPIDEMIC. TODAY, WE ARE CONFRONTED WITH A 1,660,000 ACRE MOUNTAIN PINE BEETLE EPIDEMIC IN WHICH THE MORTALITY IS OVER 1 BILLION BOARD FEET IN LODGEPOLE PINE AND OVER 200 MILLION BOARD FEET IN PONDEROSA PINE. A BUILDUP OF DOUGLAS-FIR BARK BEETLE AND FIR ENGRAVER BEETLES (SCOLYTUS) OCCURS ON THE DOUGLAS-FIR TUSSOCK MOTH WEAKENED TREES. WE ARE NOW EXPERIENCING A RAPID BUILDUP IN LARCH CASEBEARER. ROGER RYAN, PROJECT LEADER, FOREST SCIENCES LAB, CORVALLIS, OREGON, SAMPLED THE OVERWINTERING LARCH CASEBEARER POPULATION ON FIXED PLOTS NEAR ELGIN, OREGON AND REVEALED A BUILDUP OF 500 PERCENT TO 800 PERCENT ABOVE THE 1976 POPULATION.

The 1973 Douglas-fir tussock moth epidemic occurred on over 92,000 acres of Boise Cascade's tree farm. This resulted in over 10,000 acres of dead forest and several thousand more acres in which the tops were dead or badly damaged. Millions of saplings, tomorrow's crop, were killed. Fir trees included in Defoliation Class I were salvaged from 1972 through 1975. The 1976 salvage program was geared to harvesting the dead-topped trees in Defoliation Class II. The largest clearcut as a result of this epidemic was over 1,000 acres.

Previous forest management practices favored natural regeneration and we obtained the desired stand mixture by carefully manipulating the forest cover. We are now in a container nursery (and bare root seedling) program in Northeast Oregon in which we are trying to reforest these devastated areas before they become brush fields. Ten to 30-year old forests are being replaced with expensive 1-year old plug seedlings.

Survival problems of the desired species are being experienced due to frost heaving and due to high soil temperatures during the hot summer months. Competition from grass and forbs is high. Big game animals and rodents are taking their toll. As a result forestry isn't easy or fun anymore.

INSECT CONTROL AND RESEARCH PROGRAMS

During periods of economic recession it appears that research programs are the first to be slashed and the last to have their funds restored. These conditions have delayed research badly needed by the forest land managers. The forest insect problems

in the United States and Canada are examples of serious environmental concerns and forest insect management problems. We are losing the forest insect battle. There aren't many acres in the United States or Canada free from some type of forest insect infestation. The Blue Mountains has suffered two major forest insect epidemics with possibly the third under way.

Tom Ferschweiler, in the July 29, 1976 Oregon Journal stated, "Foresters in the vast woods country of Northern Maine aren't generally impressed by the tales of Oregon's tussle with the tussock moth and mountain pine beetle.

"The infestation by these two insects hit about 2 million acres of Oregon forest land.

"Maine is trying to contain the spruce budworm. Estimates of the infestation in Maine range from 8 million to 10 million acres; and across the border in Canada, a border the budworm doesn't recognize, the worms are eating trees on more than 100 million acres, roughly an expanse the size of Oregon and Washington combined."

These two great countries should be concerned over this situation. One area shouldn't be played off against the other. We believe that it is tragic for any forest to suffer this loss when forest resources are so badly needed to meet today and tomorrow's needs. There is no way that forest land managers can achieve the national wood fiber goals if they cannot protect their forests.

A FOREST INSECT MANAGEMENT PROPOSAL

THEREFORE, I AM SUGGESTING THAT THE MEMBERS OF THE WESTERN FOREST INSECT WORK CONFERENCE, THE PROFESSIONALS IN THE FOREST INSECT FIELD, DEVELOP A FOREST INSECT MANAGEMENT PROGRAM FOR CANADA AND THE UNITED STATES . . . INCLUDING FOREST INSECTS AFFECTING TREE SEEDS AND CONES, FOREST NURSERIES, PLANTATIONS, AND IN THE VARIOUS STAGES OF THE GROWING FOREST.

THIS INTENSIFIED FOREST INSECT PROGRAM SHOULD INCLUDE THE NECESSARY RESEARCH, CONTROL MEASURES, FINANCING, AND TIME-TABLES NECESSARY TO PROPERLY MANAGE FOREST INSECTS.

THIS FOREST INSECT PROGRAM SHOULD CONSIDER THE DEVELOPMENT OF THE TECHNIQUES NECESSARY TO ACCURATELY SAMPLE FOREST INSECT POPULATIONS, THE FACTORS THAT ALLOW RELEASE OF THESE POPULATIONS, AND WHAT DAMAGE IS CAUSED BY THE VARIOUS POPULATION LEVELS IN ORDER TO MAKE ECONOMICALLY SOUND DECISIONS ON THE VALUES OF CONTROL MEASURES. ADDITIONAL CONSIDERATIONS SHOULD BE TO INVESTIGATE THE INTERACTION OF INSECT-DISEASE COMPLEXES; IMPROVE SHORT-RANGE CHEMICAL PESTICIDE CONTROL TECHNIQUES WHILE LONG-RANGE, FULLY INTEGRATED PEST MANAGEMENT STRATEGIES ARE BEING DEVELOPED; AND DETERMINE THE IMPACT OF INSECT PEST OUTBREAKS AND CONTROL EFFORTS ON WATER, TIMBER, UNDERSTORY VEGETATION, AND RECREATIONAL USE OF FOREST AREAS.

THIS FOREST INSECT MANAGEMENT PROGRAM SHOULD BE PROVIDED FOR THE VARIOUS FOREST PEST ACTION COUNCILS LOCATED THROUGHOUT THE COUNTRY TO PRESENT TO THEIR RESPECTIVE GOVERNMENTS FOR THE NECESSARY AUTHORIZATION, APPROPRIATIONS AND PERSONNEL.

It is difficult to deter an idea when its time has arrived. I hope this proves to be the case with this program. When considering the 15.1 billion board feet of annual mortality, the cost and damage coupled to insect epidemics in the United States, it appears to be timely to reassess the National Forest insect program. It would appear that the Congress' attitude toward increasing immediate appropriations for forest insect research and control to minimize long-range losses and expenditures would be favorable, especially when considering the original price tag coupled to the salvage and rehabilitation program for the mountain pine beetle in the Blue Mountains was $133,000,000.

WORKSHOP: BARK BEETLES: SURVEYS AND APPLIED CONTROL
Moderator: M.D. McGregor
Participants: C.D. Minnemeyer, R. Stevens, D. Schmitz, D. Parker, J. Schenk, S. Whitney

In Region 2, (Colorado, Wyoming, North Dakota, South Dakota) major bark beetle problems are spruce beetle, _Dendroctonus rufipennis_, and mountain pine beetle, _Dendroctonus ponderosae_, in lodgepole pine and ponderosa pine. There are no serious spruce beetle infestations. Substantial infestations of _D. ponderosae_ occur in lodgepole pine near Lander, Wyoming and in the Middle Park area of Colorado. Currently there are massive outbreaks of _D. ponderosae_ in ponderosa pine along the Front Range of Colorado and in the Black Hills of South Dakota and Wyoming.

Surveys are used for detection, collection of insect brood information, and evaluation of infestation trend and effect on host stand. Aerial surveys are used for detection. Brood counts are collected for use with sequential sampling plans. Strip cruise and variable plot surveys are conducted to determine infestation trend and effects of an infestation on a forest and characteristics of a forest which encourage and prolong insect outbreaks.

In the Front Range of Colorado, the Colorado State Forest Service along with private landowners have used direct chemical control in "Designated Control Areas". Additional infested trees have been removed for firewood consumption in metropolitan areas along the Front Range. A lack of a significant timber industry has limited the use of salvage efforts or silvicultural treatment of infested areas.

In the Black Hills a major salvage logging program has been underway for several years. Over 300,000 _D. ponderosae_ infested trees were removed in each of the past two years. Efforts are being made to change the emphasis from salvage logging to silvicultural treatment to prevent bark beetle losses; however, this change is slow in taking place.

A combined salvage sale and silvicultural thinning is underway to reduce bark beetle losses in lodgepole pine near Lander, Wyoming.

Mountain Pine Beetle - Second-Growth Ponderosa Pine Stands

The major problem areas are the Front Range of the Rocky Mountains in Colorado, from south of Colorado Springs to about the Wyoming border, and the Black Hills of South Dakota and Wyoming. Survey reports are regularly prepared by the USFS, R-2 Pest Management staff; these techniques, etc., are not discussed here. I will not indulge in semantic exercise regarding the meaning of "control".

Applied control is exemplified by a program underway in Colorado, in which only selected areas called Designated Control Areas, or DCAs, are specified for efforts to minimize losses. (The outbreak is so extensive that essentially no thought has been given to attempting control over its entirety). Landownership in the infested area is largely U.S. Forest Service and private citizens and groups. Timber production is not an important factor. Many landholdings are small, down to city lot size. Values center on trees' usefulness to provide shade, pleasing esthetic effects, and the like.

Establishment of DCAs and conduct of control work has largely been furthered by leadership from the Colorado State Forest Service. Cost-sharing is practiced in some instances, with the State and Federal governments participating with private landowners. DCAs ideally are established along topographic or type change boundaries that make control practical, and in which landowners all agree to participate. Methods employed, to one degree or another, include chemicals to prevent brood emergence, salvage logging, spraying to protect individual high-value trees, and thinning.

The objective is to minimize catastrophic losses on the DCAs. Success has been variable, considering the number of factors involved. The programs have been well accepted, and appear to be achieving their objectives in certain instances.

Pine Engraver Beetles.

The existence of extensive acreages of mature timber in the West susceptible to chronic insect infestation, particularly bark beetles, ensures that most research, development, and application efforts are concentrated in this age class. As a result, bark beetles that infest younger stands, especially

those with short-lived enzootic periods such as the pine engraver, _Ips pini_, receive much less attention. Accordingly, there has been little change in survey and control techniques.

The most common form of survey continues to be the aerial detection survey during which the location and approximate number of trees in each ifestation center are mapped. Damage is expressed in terms of the number of such groups or may be further quantified by noting the number of groups of a particular size (i.e., 10 tree, 100 tree groups). No practical system for predicting damage by _Ips_ based on current population densities is available.

Lack of an effective predictive technique is due in part to the fact Ips produce multiple generations annually. This rapid development precludes use of existing technology to locate and measure population densities before the brood completes development. Sampling is further complicated by the tendency of F-1 adults to aggregate in standing green trees at higher than usual densities and totally mine the inner bark, thereby destroying this substrate for any developing larvae. This severely limits larval survival and likely reduces the rate of population increase, rather than perpetuating or increasing population densities. Accordingly, damage by the F-1 adults may or may not reflect potential for future damage.

Most land managers are encouraging preventive suppression measures rather than direct control, because the enzootic phase of these infestations seldom lasts more than 1 or 2 years. For example, in Oregon, the Department of Forestry requires landowners requesting technical advice on beetle control to develop a management plan for the acreage involved. Such plans encourage thinning at an early age to avoid accumulations of large amounts of susceptible slash and also to improve the overall vigor of such stands. In sourthern Idaho, where late winter and spring logging slash contributes to the _Ips_ problem, restrictions have been placed on time of logging in areas where _Ips_ are a severe problem. This action minimizes the likelihood of rapid population increases due to large accumulations of lsash

Although the status of current research on bark beetles is the subject of a concurrent workshop, it is appropriate here to note that efforts are underway to improve the technology

available to minimize-tree killing by Ips. Recent study of the pheromone complex of Ips paraconfusus Lanier revealed that 2-methyl-6 methylene-7 octen-4-ol, commonly known as ipsenol, blocks response of I. pini to point sources of attraction. Field tests to determine more precisely how effective ipsenol may be in blocking response to attractive bolts are planned during 1977 by the Pacific Southwest Forest and Range Experiment Station, Davis, California, in cooperation with Oregon State University, Corvallis, Oregon, in southern Idaho; and by the Intermountain Station and the Idaho Department of Lands, in northern Idaho.

Roundheaded Pine Beetle

The roundheaded pine beetle, Dendroctonus adjunctus has repeatedly depleted ponderosa pine stands in south-central New Mexico. The types of trees killed by this bark beetle and associated bark beetles, and the extent of mortality was not known until 1974 from results of surveys of infestation centers in 1971 and 1972.

Six areas were chosen for sampling to represent what were judged typical infested stands. Forty to 248 fixed plots were systematically sampled to determine the stand structure for all live and dead trees.

Losses ranged from near zero to over 50 percent of the ponderosa pine stand component, both in number of trees and basal area per acre. Infested trees averaged 6.5 inches d.b.h.

Results of damage surveys provided land managers with information needed to determine that prevention, suppression, or salvage programs were not viable alternatives. Even though roundheaded pine beetle infestation trends are determined by entomologists on an annual basis, no direct actions are taken in response to beetle-caused mortality. Land managers determined this "do nothing" approach was most consistent with management and environmental concerns for the mixed, second-growth forest stands where tree losses were occurring.

Fir Engraver Beetle - Grand Fir Stands in Idaho

Stands examined were grand fir or Cedar/Pachistima Habitat Types. Study plots were about 10.1 ha in size; were located in stands to provide a range of densities and species composi-

tion; and where Grand fir comprised 50% of the volume by species.

In 12 stands examined, all species were recorded by d.b.h. and Grand fir mortality caused by fir engraver beetle was recorded for a 3-year period. All grand fir on plots were felled and 5 bolts were removed/tree, 3 at lower third, and 1 each from middle and upper thirds and examined.

In developing a model, stand susceptibility is a function of stand density and host availability (H1). CCF (crown competition factor) was selected as a measure of density because competition between trees in a stand for crown space begins when all space is occupied, and each tree crown is equal in area to that of an open-grown tree of the same d.b.h. (thus CCF = 100). Density can be expressed as a percentage. Krajicek et al., (1961) believes that a consistent maximum exists for each tree species, the magnitude of which depends on: (a) characteristics of crown development without competition; (b) basic shape of the crown; and (c) shade.

As stands become more dense, competition increases, and trees become less vigorous. Thus, in dense stands, the relative proportion of trees susceptible to successful attack should increase. (Presence of predisposing factors such as root disease and drought would further increase numbers above normal).

Stands with a high CCF usually contain a greater number of larger diameter trees and, more critically, these trees would likely be under competitive stress and also would be the most beetle productive individuals in the stand.

Data needed to derive CCF and Diversity Index (DI) values are (species, d.b.h., and number of stems on a fixed or variable plot). These are normally acquired during standard timber inventories.

Diversity index expresses the uncertainty attached to the specific identity of any selected individual. The greater the number of species and the more nearly equal their proportions, the greater the degree of uncertainty and thus diversity. Diversity index used is a modified version of Brillouin's (1960) because each observation was weighted by that tree's diameter.

The inclusion of tree size, in addition to number of trees, resulted in an expression of the relative availability of potential beetle habitat.

The model that best described the data took the form of: (Figure 1)

$$Y = -2.24 + 1.44\ 759e^{X}$$

where Y = # of engraver beetle killed trees/ha over 3 years.

$$Y = \text{stand hazard rating} = \frac{CCF/(K+DI)}{100} \qquad K = .01 \text{ a constant}$$

and $R^2 = 0.82$

SE = 2.03 trees/ha.

A second model in which the dependent variable is expressed as percent grand fir killed/ha took the logistic form: (Figure 2)

$$\text{In } \left(\frac{K}{Y} - 1\right) = 0.0526 - 0.00068X$$

where: K = 2
X = SHR
Y = 1 + % of the total GF stems killed over 3 year period upper and lower asymptotes = 100 + 0, respectively.

Both the absolute number of trees killed and rate of tree mortality showed similar patterns with increasing hazard rating (Figures 1 and 2). This suggests that rate of mortality actually is higher in dense-pure stands, and that higher mortality levels are not merely a function of greater numbers of GF in these stands.

Recent validation (In Prep.) in 8 new stands has shown excellent agreement between predicted and actual GF mortality/acre.

The model is intended for use in GF dominant stands (those who weighted value for GF is numerically greater than that for any other individual tree species, and mean stand d.b.h. greater than 15.2 cm).

FIGURE 1.

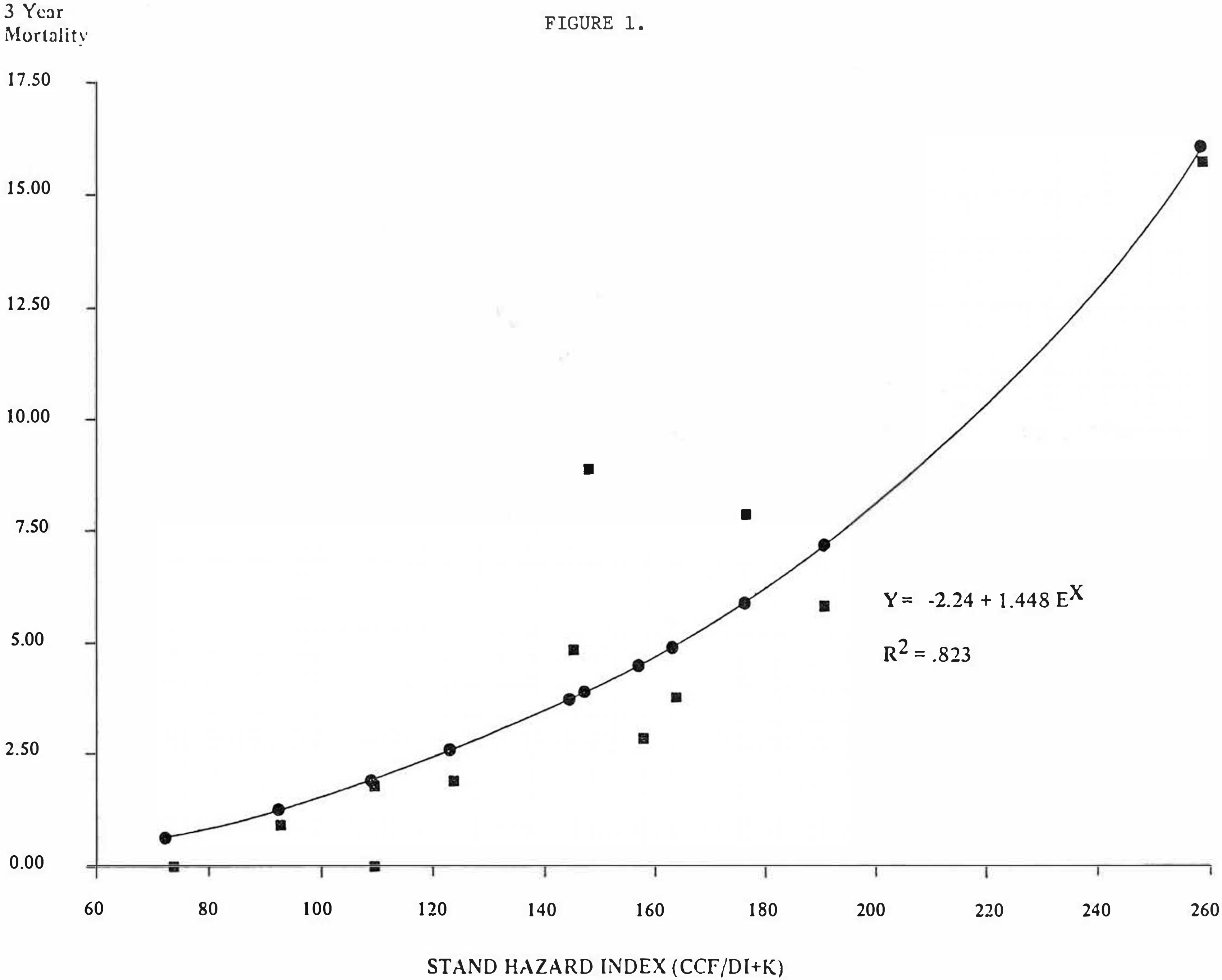
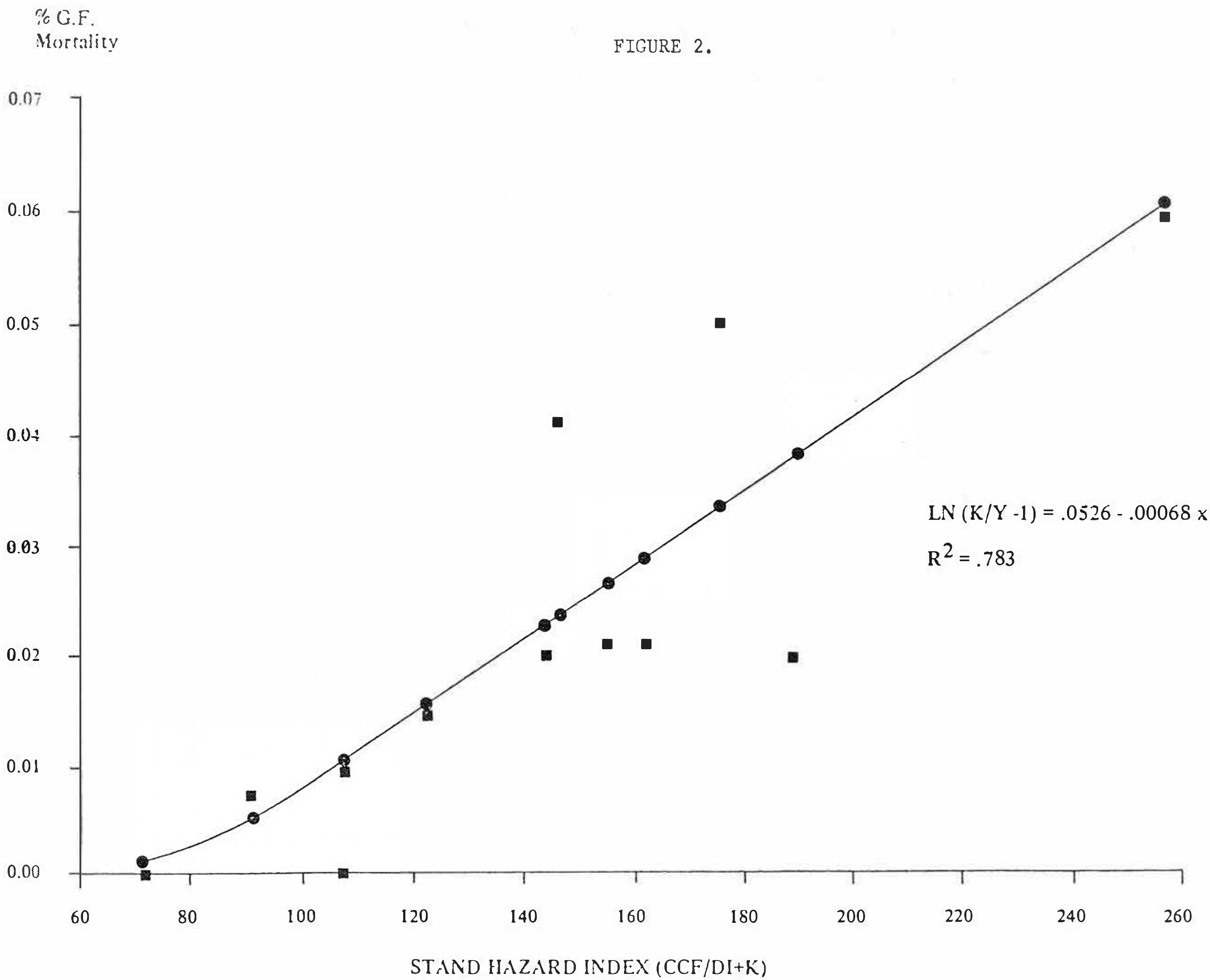

3 Year
Mortality
17.50
15.00
12.50
10.00
7.50
5.00
2.50
0.00
60
80
100
120
140
160
180
200
220
240
260
Y= -2.24 + 1.448 E^X
R^2 = .823
STAND HAZARD INDEX (CCF/DI+K)

FIGURE 2.


% G.F.
Mortality
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
60
80
100
120
140
160
180
200
220
240
260
STAND HAZARD INDEX (CCF/DI+K)
LN (K/Y -1) = .0526 - .00068 x
R2 = .783

Based on currently available data, stands with a SHR $>$ 160 should be assigned a higher probability of epidemic infestations that those $<$ 160. DI's may range from 0 ca 3.0 for most GF stands. Given a DI of 1, GF stands $<$ 160 CCF would be high hazard (2.02 trees killed/ha), while those $>$ 200 CCF would likely suffer greater than 2.02 trees/ha. Using simulation techniques, managers may project a stand through time and, by computing SHR at intervals during projection period, identify those stands most likely to sustain epidemics, and when they will likely occur. Because the SHR model uses variables easily manipulated through silvicultural practices, it would be a direct procedure to evaluate consequences of alternative management regimes in terms of the conditional probability of engraver beetle outbreaks. This should improve our capabilities for rational planning and informed decision-making.

Results also suggest that managers can reduce extent or potential of engraver beetle-caused Grand fir mortality by altering composition and density. The approach may also prove useful in quantifying insect-host interactions for other bark beetle-tree species ecosystems. Preliminary models for lodgepole pine caused mortality caused by D. ponderosae has also shown promise.

The three agencies; (1) Provincial, (2) Federal governments, and (3) the private Forest Industry and their review committee are responsible for forest management.

The province owns virtually all forested land in its domain. As landlord this government (through the British Columbia Forest Service, BCFS) has the primary responsibility for administration, management, protection and utilization of the forest resource and it develops policy and enforces rules and regulations relevant to forest protection, i.e., bark beetle control.

The Federal government (Canadian Forest Service) has a mandate to provide expertise in forestry development and research aimed at supporting the provincial government in its management, protection, and utilization activities. Additionally, the CFS has developed a detection and appraisal capability in its annual Forest Insect and Disease Survey (F.I.D.S.).

The private forest industry is involved primarily by responsibilities delegated from the BCFS through various harvesting agreement.

The BC Forest Pest Review Committee is composed of representatives of forestry and all related interests from both provincial and federal governments and from industry. This committee meets annually and reviews, coordinates, and recommends on policy and problems and action of, for, and to all its relevant agencies in matters pertaining to forest pests.

A Case History:

Primary Detection by Woods Operators (Industry or BCFS or FIDS Officer on regular annual inspections	reported by	Company Forester or BCFS Ranger	referred to	FIDS	Identification preliminary appraisal biological evaluation waxing, waning?

Bi-weekly report to	FIDS Synthesis & Recommendations Analysis, Advice	Conveyed to-	Alternatives Decisions	Do Nothing - accept losses Get more damage info. e.g. limits of green infestation.

May lead to	Salvage Logging Sale	Rapid processing of administrative detail hot logging = rapid extraction & concession

If required	BCFS subsidized conversion and marketing

Continuing annual surveys by CFS - FIDS are necessary to update activities in Mountain Pine Beetle Surveys and Control. CFS is active in five areas re-control; three with direct control, one with usefulness of mpb killed timber and one of continuing education and extension of current knowledge by way of workshops, seminars and awareness campaigns aimed primarily at forest resource managers and woods operators.

BC Forest Pest Review Committee Task Force on mpb - what it means to BC forestry and what can or should be done about it. Crown Zellerbach - Kelowna, B.C. recently established a containment corridor (9 miles long x 500 - 1,000 feet wide = 3,000 acres) to control mpb spread. It has not been too effective.

In the Northern Region (Montana and Idaho) D. ponderosae populations are epidemic in lodgepole pine stands on about 364,230 ha of National Forest, State & private lands and lands administered by the National Park Service.

As Annual Aerial Insect and Disease Detection Surveys are completed, estimates of tree and volume loss/ha, buildup ratios and size of infested area are obtained based on establishing forty 0.10 ha plots at 100 meter intervals or survey lines 100 meters apart within infested areas. Hypometers are used to determine if trees occur within plot boundaries. Each infested trees 13 cm d.b.h. and larger is recorded by d.b.h. and categorized as to green unifested and year of kill if attacked.

Phloem thickness tree diameter distribution of logepole pine within the remaining green stand is obtained from twenty 0.04 ha plots located at 100 m intervals on lines 100 m apart. Hypometers are used to determine trees to be tallied within plots. Trees are recorded by d.b.h. and two phloem samples are removed with a hand axe from appropriate sides from each of two tree/ diameter class/plot. Phloem thickness is measured to the nearest 0.02 cm with a steel ruler.

The frequency of epidemics appears to be directly related to site quality, age, phloem thickness, tree diameter distribution within the stand, and elevation and latitude.

Amman et al., (In Press) developed a hazard rating system for mountain pine beetle in unmanaged lodgepole pine stands which includes factors such as: (1) age, (2) elevation and latitude, and (3) average d.b.h. for the stand. Generally, stands must be $\geq$ 80 years old; located at an elevation where climate is favorable for brood development; and average d.b.h. of the stand for trees $\geq$ 12.7 cm must exceed 20.3 cm. These factors are being used in hazard rating stands in the Northern Rocky Mountain area. By multiplying the following factors, 1 = low, 2 = moderate, and 3 = high, for age, elevation, and average d.b.h., susceptibility classification of stands is obtained:

Elevation Latitude	Average age	Average d.b.h.
High (1)	<60 (1)	<7 (1)
Moderate (2)	60-80 (2)	7-8 (2)
Low (3)	>80 (3)	>8 (3)

The following is an example of hazard rating:

Table 4.--Hazard rating for lodgepole pine stands surveyed, Gallatin District, Gallatin National Forest, 1976.

Area	Av. Age Lpp	Rating	Elevation	Rating	Av. d.b.h. in cm's	Rating	Overall Rating	Hazard
Spanish Ck	80+	3	6200-8000	3	25.1	3	27	High
Squaw Ck	60-80	2	5600-8400	3	18.0	3	18	Moderate
Cascade-Lava	60-80	2	5600-8400	3	26.0	3	18	Moderate
Karst	80+	3	5800-8400	3	24.6	3	27	High
Tamphrey	80+	3	5800-7600	3	24.6	3	27	High

Hazard rating uninfested stands, provides direction to land managers in predicting when stands will reach the age and size class distributions conducive to beetle epidemics. Plans for harvest of moderate and high hazard stands can be made years in advance.

Stands that have a high risk of infestation and subsequent loss to the beetle can be dealt with in several ways, depending upon land management objectives:

<u>Where Timber Values are Primary</u>

1. Recognizing that the beetle concentrates heavily on trees of large diameter, continuous lodgepole forests can be broken up into small clearcuts resulting in different age and size classes, thereby reducing the area likely to be infested at any one time.

2. Since the beetle shows preference for trees of large diameter, partial cuts directed at these trees will greatly reduce infestations. Removal of most trees 20.3 cm d.b.h. and larger would "beetle proof" most stands.

Selective cutting may not be the best method to manage infestations in understocked or overstocked stands on good sites. In such stands, a high proportion of trees in diameter classes < 20.3 cm d.b.h. may have thick phloem. Brood production could continue to be high enough to continue the infestation, resulting in considerable tree mortality. Clear-cutting and regenerating the stand may be the best method of handling high risk understocked or overstocked stands on good productive sites.

3. Harvesting trees before they reach sizes conducive to beetle outbreaks would be an effective method of preventing losses to the beetle where markets for small diameter material exists.

4. Another alternative for stands that are particularly susceptible to beetle attack is to favor nonhost trees such as Douglas-fir, Engelmann spruce, subalpine fir or western larch. If the manager elects to convert lodgepole pine forests to other species, he can expect losses by other insects as these stands become susceptible.

Management of Recreation Areas

Forests committed to recreation use such as National and State parks, Wilderness Areas, and other forested land not included in the timber growing base may not require action against the beetle. In seral lodgepole pine forests protected from fire, the proportion of other tree species can be expected to increase with each beetle infestation, until succession is complete and both lodgepole pine and beetle would be eliminated from the stand.

Conversion of noncommercial lodgepole pine forests to non-host species of trees will eliminate the possibility of beetle populations building up and moving from noncommercial to adjacent commercial forested land. Conversion of lodgepole pine forests can be expected to occur naturally in the absence of fire where lodgepole pine is seral, being succeeded by Douglas-fir at lower elevations and subalpine fir and Engelmann spruce at higher elevations. Fire occurring prior to completion of succession would revert some of these stands back to lodgepole pine, and another beetle cycle.

In stands where lodgepole pine is climax, periodical infestations of the beetle can be expected as a portion of the stand

grows into large diameters having thick phloem, conditions needed by the beetle. Openings created in the forest when dominant and codominant trees are killed by beetles are seeded by lodgepole, thus forming an uneven-aged, multi-storied forest.

Where Individual Trees Have High Value

Trees in picnic areas, campgrounds, around visitor centers, and summer and permanent home sites have much higher value than trees in the forest situation. Chemical sprays offer promise for protection of such trees. A single application before flight and attack by the beetles has prevented attacks for one year and, in some instances, through a second year.

Managers of high-use recreation areas should also consider planting trees of different species where lodgepole pine trees have been killed. Thus shade and esthetics will be preserved as other lodgepole pines die or are killed by beetles.

Preliminary results of using fire to control mountain pine beetle was provided by S.J. Muraro. Environmental conditions of recent years have favoured the development of epidemic populations of Mountain Pine Beetle, (*Dendroctonus ponderosae* Hopk.), in British Columbia. Regional differences in the value of lodgepole pine throughout British Columbia strongly influences the current justification and application of traditional control techniques. In areas where lodgepole pine is not in current demand, there is a particular need for effective control techniques that are not dependent on harvest operations. In these instances prescribed fire may offer an economical and environmentally compatible control tool with the distinct possibility of additional stand improvement benefits. The lack of success of early researchers to use fire in the control of *D. brevicomis,* and their conclusions regarding the complex interplay of beetles, Ponderosa pine and fire can be summarized as follows:

1. *D. brevicomis* are attracted to trees in various states of stress resulting from crown scorch rather than immediate fire related phenomenon such as smoke heat or smell.

2. Survival of broods established in fire damaged trees is generally poor.

3. Because of the thick bark common to ponderosa pine, fire caused mortality of all stages of D. brevicomis is virtually non-existent.

4. Because of enhanced stand vigor and reduced competition light to moderate intensity fires reduce the long term susceptibility of stands to D. brevicomis.

In contrast, D. ponderosae appeared to be strongly attracted by immediate fire phenomenon. In addition to this apparent difference in attractiveness to burned areas, the very characteristics of ponderosa pine that precludes the effective use of fire on the D. brevicomis suggests that fire may be a viable tool for control of D. ponderosae in lodgepole pine stands of Idaho.

Consultation with Caribou District protection personnel established the need to develop or demonstrate control techniques for using fire where harvesting control programmes are not feasible and to develop the fire prescriptions, costs and field techniques to allow operational application for:

1. Low density single or multiple tree infestation.

2. High density single or multiple tree infestations.

3. Well defined concentrated infestations of varying size.

Low density single tree of multiple tree infestation.

This situation may be characterized by scattered single or small clumps of infested trees characteristic of incipient increase in beetle populations. This situation demanded an economical and logistically favorable method of treating a few infested stems at scattered locations. The single tree burning technique in the western states in the late 20's and early 30's seemed promising especially when considered in light of modern portable pumping and vehicular equipment. The concept of winter application from snowmobiles to avoid the need for the time consuming fire control work was proposed. Other advantages of winter treatment included protection of beetle predators in the duff and ease of cross country travel on favorable terrain and a long period of control work.

To test the usefulness of the technique, burning tests were conducted on a number of frozen bole sections removed from infested trees. These tests served to determine appropriate fuel mixes, quantities and application periods. Pre and postburn plus two week populations were sampled and underbark temperatures were continuously recorded at four locations in the course of the tests. These limited tests indicated that a mixture of 90% diesel and 10% gas provided easy ignition and sustained burning. Pre soaking the boles and repeated addition of fuel to maintain fire for a minimum of three minutes provided lethal underbark temperatures of 46°C. In general this corresponded with the guide provided others of maintaining fire until the edges of the bark flakes turned to white ash. Essentially all beetle populations were killed except under areas that had obviously not been adequately scorched.

Further demonstration and testing of the techniques was conducted in May and June of 1976 using a Forest Service suppression crew and their standard initial attack equipment. The areas treated were readily accessible to 4 wheel drive vehicles fitted with standard 125 gallon porta-tanks, one filled with water and a second trailer mounted unit filled with a 10% gas, 90% diesel fuel mix. Changing the pump unit to a centrifugal pump and the use of a #4 nozzle tip was the only equipment modification required. A delivery rate of .007 gal/min at 100 PSI allowed a two man crew to treat a tree in about five minutes. As in the preliminary tests pre and post-burn population sampling showed that conscientious application of fire was 99% effective on adults and 87% effective on larvae. Areas of only slight scorch and light discoloration maintained living beetles.

The equipment used generally limited the treatment height to about 16 m especially in windy conditions. One strong advantage was the utilization of staff and equipment that did not detract from the crews regular duties of initial attack on fires. Application of this technique using snowmobiles is currently being conducted on spot infestations in the West Chilcotin.

High density single or multiple tree infestations.

These infestations are similar to the low density infestations except for the increased number of trees attacked and frequency of small groups of attacked trees. These areas generally represent a later period in the development of an infestation or in the case of mixed stands may represent all of the available food supply. In so far as control is concerned the numbers and distribution of infested trees preclude an individual tree approach. In general, the traditional area harvesting technique would be the recommended control measure.

The purpose of this series of studies was to test the biological and environmental impact of controlled intensity surface fires on the development of D. ponderosae populations. This approach proposes that an area control approach is feasible by manipulating fire behavior to maintain a controlled intensity surface fire to minimize damage to the Douglas-fir component of mixed pine stands. This can be readily achieved by strip ignition with careful attention to modification of strip spacing inversely with local fuel conditions. Differences in crown moisture content and bark characteristics suggest the possibility of selectively candling and greater scorch heights on infested trees. In addition to killing developing broods of D. ponderosae, stand sanitation and reduction of competition to the residual stand could occur. The attractant feature of fire injured trees and the generally poor survival of new broods would have additional adverse effects on surrounding populations of the beetle.

Due to the wet summer of 1976 only one 2.0 ha area was subjected to moderate intensity fire on July 25, just prior to the main emergence period.

Preliminary results show that population mortality will result if the bark of infested trees is scorched. In our situation there was difficulty in maintaining sufficient fire intensity in these areas of light fuel. Of 136, 10 cm diameter core samples only 38 received some degree of char. They contained an average of 20 new adults and 17 larvae per square meter compared to 72 and 27 adults and larvae from the uncharred cores. Only four beetles emerged from the 38 traps in charred areas versus 124 in the uncharred portions of boles.

The residual stand of small pine and Douglas-fir were crown scorched to varying degrees but generally had a high rate of fire survival. Immediate heavy attacks by both _Ips_ and _D. ponderosae_ resulted in infestation of all the lodgepole pine. The newly attacking _D. ponderosae_ showed a definite preference for uncharred bole areas of fire damaged trees, however, succeeding attackers did eventually move into charred areas. By late November broods of the new attack were well developed, however, loosening of the bark on the charred areas was already underway. Moisture content of living bark samples ranged from 23 to 30 percent whereas fire killed bark ranged from 49 to 64 percent moisture content. Ice crystals were present in the loosened, damaged bark whereas none was present in the undamaged bark. Certainly the chances of brood survival seem much reduced under fire damaged bark.

Final assessments of fire impact on attacking and brood survival are scheduled for 1977.

Well defined concentrated infestations.

These infestations are characterized by more or less discrete areas of almost continuous attacks and represent advanced infestations. An area approach to control over relatively large areas is required. Salvage values may be negligible or moderately high but due to the inability to log as fast as the beetle spreads the priority for control exceeds the values at stake. In these situations a high intensity broadcast burn of the infested area may be the most economical control measure. In areas of high salvage value where markets are available this technique could compliment a fibre extraction process at a cost commensurate with the loss resulting from beetles alone.

Conventional extraction methods for control are often unsuccessful because the beetles emerge and spread faster than logging can progress and because of the lack of followup control work outside the perimeters. In many instances there is not sufficient logging capability to clear the infested trees before the next flight period. The limited logging capability could be applied to log and extract the fibre from a 200 meter wide fire guard surrounding the infestation. Concurrent with construction and logging, surveillance and individual tree control is conducted outside the main infestation. After completion of the guard,

prior to flight, the infested area is burned to kill resident beetles and to utilize other detrimental fire impacts to beetle populations. Logging of fire killed timber may then continue for a varying length of time until the wood is no longer useable. Where markets are not available, the procedure is one of guard construction and prescribed burning with the desired intensity.

Study areas for this application of fire were established in 1976, however, weather conditions did not permit burning. These areas are scheduled for completion in 1977.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle
Survey & Controls
Moderator: M. McGregor

Name	Insect species: Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips spp.	Others (specify)	Fields of work: Control: Microbials, biocides	Parasites, Predators	Chemicals	Cultural	Other (specify)	Surveys: Impact	Detection and population surveys	Sampling method development	Other (specify)	Comments: Please specify the nature of your work
Ernie Morris														x			Forest Insect and Disease Survey (Victoria PFRC)
Dick Andrews														x			Forest Insect and Disease Survey (PFRC)
Vernon Craig												x				x	Pest Management B.C. Forest Service - Kamloops Forest Dist.
Charles D. Minnemeyer	x		x										x	x	x		Forest Insect & Disease Management USDA Forest Service, Region 2, Denver, CO
Kenneth R. Lewis										x							Product Development Agricultural Products, Union Carbide Corp., Salinas, CA
James A. Moore							Fir Engraver					x					Hazard Rating Grand fir stands for mortality by Fir Engraver College of Forestry, Univ. of Idaho, Moscow
William L. Leuschner					x												Project includes individual tree stand projection model to simulate physical impact and development of benefit-cost framework for economic evaluation.

Bark Beetle Survey & Controls Moderator: M. McGregor	Insect species							Fields of work									Comments
								Control					Surveys				
Name	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips spp.	Others (specify)	Microbials, biocides	Parasites, Predators	Chemicals	Cultural	Other (specify)	Impact	Detection and population surveys	Sampling method development	Other (specify)	Please specify the nature of your work
A. T. Larsen																	Administration - surveys and control on state and private lands
Dick Schmitz	x					x				x Behavioral	x						Follow ecology of endemic MPB in lodgepole to better understand what triggers outbreaks. Develop guidelines for suppressing I piri population including cultural and behavioral chemicals.
John A. Schenk	x						Fir Engraver		x		x		x				Stand hazard rating for S ventralis and D. ponderosae Preventative control strategy thru cutting practices effects on logging on popucatious and damage.
Jerry Knopf	x	x		x		x	DFTM			x		Pheromones		x			Detection and evaluation (aerial surveys) special bio evaluations. Providing ento. info to land mgrs.
Paul Buffam					x					x	x		x	x	x		Monitor and coordinate research and development activities for SPB RD&A Program.
Rick Johnsey																x	Working in defoliators - primary objective of attending bark beetle workshop is to check current status of the art
Dave Parminter	x					x	Root rots					Harvest					Directly involved in locating, mapping, and prescribing, land management objectives through intensive harvesting practices.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetles Survey & Control Moderator: M. McGregor Name	Insect species							Fields of work: Control					Fields of work: Surveys				Comments
	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips spp.	Others (specify)	Microbials, biocides	Parasites, Predators	Chemicals	Cultural	Other (specify)	Impact	Detection and population surveys	Sampling method development	Other (specify)	Please specify the nature of your work
Stu Whitney	x		x					x									Role of microorganisms (symbionts, pathogens) in bark beetle epidemiology.
Mark McGregor	x	x				x					x		x	x			Bark beetle evaluation and management
Bob Stevens	x										x						
Jack Bailey	x	x	x			x					x		x	x	x		Responsible under Provincial Legislation to protect forests from insects.
Ronald F. Billings					x						x		x	x			Administer computerized system of record keeping for SPB detection and control operations; evaluate effectiveness of control tactics (salvage, habitat disruption); research on seasonal beavior.
Joe Grigel	x		x			x							x	x			Bark beetle control and management.
Galen C. Trostle	x									x							Coop. field test with PSW Sta.

Bark Beetle Survey & Controls Moderator: M. McGregor	Insect species							Fields of work									Comments
								Control					Surveys				
Name	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips spp.	Others (specify)	Microbials, biocides	Parasites, Predators	Chemicals	Cultural	Other (specify)	Impact	Detection and population surveys	Sampling method development	Other (specify)	Please specify the nature of your work
S. J. Muraro	x											Fire					CFS PFRC, Victoria. Prescribed Fire.
Rene' Alfaro	x																Graduate Student - Simon Fraser Univ.
Doug Parker	x		x	x		x					x	Salvage	x	x	x		Detection, Evaluation, Management U.S. Forest Service
J. M. Finnis	x	x	x							x			x				Forest Pest Management Protection Div. B.C.F.S.

WORKSHOP: WHO IS DOING WHAT IN BARK BEETLE RESEARCH

Moderator: Jack E. Coster

About 50 persons participated in discussions of a wide variety of topics - including Effects of optical isomerism on response of southern *Ips* to pheromones (R.L. Hedden), Aerial applications of MCH and *trans-verbenol* for inhibition of Douglas-fir beetle (G.B. Pitman), Use of frontalin in a trap-tree approach against spruce beetle (E.D.A. Dyer), Influence of photochemical toxicants on western pine beetle damage incidence (D. Dahlsten), A sampling system for southern pine beetle and associates (F. Stephen), Characterization of spruce beetle reproductive potential (T. Sahota), Electrophysiological investigations of southern pine beetle pheromone perception (T.L. Payne), and Relationship of mountain pine beetle outbreaks and fire occurrence near Crater Lake (R.I. Gara).

Survey sheets were circulated among the participants so that areas of bark beetle research interest could be determined. The sheets were posted for the remainder of the Conference.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research
Moderator: J. Coster

Name	Insect species							Fields of work									Comments
	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Please specify the nature of your work
Les Safranyik	x		x									x			x	x	Studies of the effects of management practices, stand and weather factors, predators and parasites on spruce beetle populations. Modeling spruce beetle dynamics & sampling spruce beetle populations.
Les McMullen		x														x	Relationship to defoliation. Assessment of logging practice in control.
David Dyer	x		x					x				x					Application of pheromones and impact on endemic populations.
Malcolm Shrimpton	x		x								x						Host response to mountain pine beetle and spruce beetle.
Stu Whitney	x		x							x	x						Pathogenicity of microbes to host and to the beetle avenic rearing.
Tara Sahota			x										x				Reproduction physiology and reproductive potential through measuring rate of yolk deposition.
Barry Bynum	x										x	x		x	x		Analysis of variance components in various behavioral events during attack on lodgepole pine.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research Moderator: J. Coster	Insect species							Fields of work									Comments
Name	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Please specify the nature of your work
Jim Richerson					x			x						x			Collection and assaying of II° attractants (field and lab bioassays).
Skeeter Werner			x				Larch Beetle	x			x			x			biology and behavior. Site conditions vs. attack density and brood establishment Field assys of attractants and anti-attractants.
Al Stage	x						DFTM								x	Impact	Modeling stand/forest dynamics.
Ken Raffa	x						Fir Engraver				x						Host resistance, hypersensitive reaction.
Larry Wright							Scolytus				x	x					Affects of defoliation on host resistance and beetle dynamics.
Nicholas L. Crookston	x															Impact	Climatic factors and history of MPB in LPP.
Jerry D. Guenther	x															Biochem. genetics	Gathering biochemical genetic data at the species leve.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research Moderator: J. Coster	Insect species							Fields of work									Comments
Name	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Please specify the nature of your work
Lula E. Greene				x	x											Photo detection	Mapping pine mortality as an aide in insect detection.
R. C. Heller	x	x					DFTM									Remote sensing	Remote sensing. Previsual detection of bark beetle attack.
Bill Livingston							Pseudo. granul			x							Finding out if possible vector of root diesease in grand fir.
John Byers				x		x		x			x		x	x			Physiology of Pheromone production. Behavioral responses of b.b.'s to pheromones.
Henry Moeck			x					x			x			x			Primary attraction - field and lab bioassays, gas chromatography of extracts of host tissue.
Joe Elkinton						x					x			x			Host selection behaviro of Ips. paraconfusus.
Lee Ryker		x						x						x			Sound & pheromone communication.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research Moderator: J. Coster	Insect species							Fields of work									Comments
Name	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Please specify the nature of your work
Oscar Spauoer	x		x							x							Emphasis on biological control.
Steve Laursen U. of Idaho, Moscow							Scolytids of G.Fir				x	x		x			Relationship between scolytid community composition - success and habitat type and commercial logging.
Bill Telfer SFASO, Nacogdoches					x							x		x			The percent of a parent adult population that can re-emerge and reattack a second host tree.
Paul C. Johnson SFASO, Nacogdoches, Texas					x							x			x		Dispersal patterns within and between infestations and modification with behavioral chemicals.
Bob Thatcher SPB R&D Program Pineville, LA					x											Admin.	Program manager for USDA South Pine Beetle R&D Program
Fred Stephen Univ. of Arkansas Dept. of Entomology					x				x			x			x		Studies on SPB population dynamics. Interests in bark beetle sampling, population prediction and the role of natural enemies in SPB dynamics.
Gary B. Pitman Dept. Forest Management OSU Corvallis, OR	x	x				x		x						x			Relationship of behavior and genetic make-up of population (MPB). Continued development of pheromone control strategies. Slash control (Ips.)

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research
Moderator: J. Coster

Name	Insect species: Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Fields of work: Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Comments: Please specify the nature of your work
Fred P. Hain NC State Univ. Raleigh, NC					x						x	x			x		Sampling and population studies of SPB. The role of stand and site facotrs in spot growth and proliferation.
W.T. McClelland NC State Univ. Raleigh, N.C. 27607					x				x		x	x			x		Same as above.
Roy L. Hedden Weyerhaeuser Co. P.O. Box 1060 Hot Springs, Arkansas					x	x		x		x	x			x			Pheromones, behavior, site-stand relationships of southern bark beetles
George Ferrel USFS PSW Expl. Sta. P.O. Box 245 Berkeley, CA							Fir Engr.				x						Risk rating systems for true-firs. Moisture stress and resistance of true-firs.
Don Dahlsten Univ. of California Berkeley, California	x			x		x			x			x			x		Development of life tables, biology of natural enemies, influence of photochemical oxidents and root diseases on beetle population.
Mark P. Chatelain Univ. of Idaho College of For., Wildlife, Range Mt., Moscow, ID	x							x	x								
John McLean Simon Fraser University Burnaby, B.C., Canada							Ambrosia	x			x			x			Suppressing Ambrosia beetle populations in commercial sawmills by use of attractants and pheromones.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research
Moderator: J. Coster

Name	Insect species: Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Fields of work: Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Comments: Please specify the nature of your work
Evan Nebeker Dept. of Entomology Mississippi State Univ Mississippi State, MS					x				x	x	x	x		x	x		Studies concerning SPB population dynamics (biology), sampling efficiencies and predicting studies. Predator-prey systems are also being investigated beginning with basic ethological studies. Diebuck in pine is also being investigated.
Dan Geiszler, U. Washington	x										x	x					Interrelationship of fire, fungi and mountain pine beetle in a lodgepole pine ecosystem. Also the switching dynamics between trees.
Robert C. McKnight School of Forestry Oregon State University Corvallis, OR 97331	x	x				x		x			x	x		x			Stereochemistry of mountain pine beetle attractants. Douglas-fir beetle population manipulation with attractants and inhibitors. Isp. piri inhibitors.
David L. Kulhavy College of Forestry Univ. of Idaho Moscow, ID	x										x						Check for association beween root decays and bark beetles in western white pine.
Joe Pase Texas Forest Service Box 310 Lufkin, Texas 75901					x						x	x					Looking specifically at spot occurrence in relation to stand conditions, time of year, geographic area, type of control applied to a spot, etc. Also looking at certain factors in relation to spot expansion. Looking at crown condition relative to brood development.
Martin C. Birch Dept. of Entomology Univ. of Ca. Davis, CA 95616				x	x	x	Scolytus Multi	x						x			1) Interactions between pheromones/other chemicals of different scolytid species-particularly Ips. in CA & TX. Mechanisms of interaction at belanoral and electrophysiological level. 2) Scolytus multistriatus pop-out strategy with pheromones.
Tom Payne Texas A&M U. College Station, Texas					x			x	x	x			x	x			Role of beetle & host -tree produced volatiles in behavior of SPB and associates. 1) Field studies, 2) lab bioassays, 3) sensory physiology

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Bark Beetle Research Moderator: J. Coster	Insect species							Fields of work									Comments
Name	Mountain pine beetle	Douglas-fir beetle	Spruce beetle	Western pine beetle	Southern pine beetle	Ips ssp.	Others (specify)	Attractants	Parasites, predators	Associated microorganisms	Host relationships	Population ecology	Physiology	Behaviour	Sampling	Other (specify)	Please specify the nature of your work
Tim Paine				x	x	x	Scolytus			x			x				Interrelationships of bark beetle - host tree - fungel physiologies
Shane Weber						x	Scolytus					x					Population build up of bark beetles in Douglas/Grand fir slash and assessment of potential danger to residual stands

Defoliators Surveys
& Controls
Moderator: F. Honing)

Name	Insect species: Douglas-fir tussock moth	Insect species: Budworms	Insect species: Larch casebearer	Insect species: Loopers	Insect species: Other (specify)	Fields of work – Control: Microbials, biocides	Control: Parasites, predators	Control: Chemicals	Control: Cultural	Control: Other (specify)	Fields of work – Surveys: Impact	Surveys: Detection and population surveys	Surveys: Sampling method development	Surveys: Other (specify)	Comments – Please specify the nature of your work
Roy Shepherd	x	x	x	x		x	x	x				x	x		Population ecology, insect behavior, sample systems, control strategy of BC defoliators.
Al Rivas					x			x		x				x	Primarily Administration, pesticide coordination
John Wear	x	x									x		x		Sequential short and long range impact surveys
G. von Westarp															Forest Management - silviculture
John W.E. Harris	x	x		x			x	x			x	x	x		Forest Pest Surveys. Development of data storage and retrieval systems. Analysis of historical data. Survey methods, particularly remote sensing; Landsat. Spruce budworm control assessment.
Robin M. Gardner	x	x	x	x	shoot moths	x		x	x						Urban Forestry. Protection of streets and harbor trees with special interest in public parks department management.
Tom Coffey	x	x						x			x		x		Insecticide field tests (efficacy and environmental impact) under contract.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators Surveys & Controls Moderator: F. Honing	Insect species*					Fields of work									Comments
						Control					Surveys				
Name	Douglas-fir tussock moth	Budworms	Larch casebearer	Loopers	Other (specify)	Microbials, biocides	Parasites, predators	Chemicals	Cultural	Other (specify)	Impact	Detection and population surveys	Sampling method development	Other (specify)	Please specify the nature of your work
Leon Pettinger		x	x				x	x				x			WSBS applied control. Larch casebearer parasite releases
David McComb	x	x	x					x				x			Biological or entomological evaluations of outbreaks. Evaluation of results of control projects. Insect development surveys for timing of control projects.
Glenn B. Parson			x				x								Bio control using introduced parasites to see if we can establish these insects in N.E. Oregon
Howard A. Tripp												x			Head, Forest Insect & Disease Survey - B.C. & Yukon Pacific Forest Research Center Victoria
Robert E. Acciavatti		x						x		Method Evaluation		x	x		Biological evaluation of WSBW Evaluate early suppression strategy against WSBW Develop sampling technique for WSBW population - host tree defoliation predictions.
C. F. Garner								x							Pesticide Research and Development
K. Stoszek	x													Risk Rating	College of Forestry, U. of Idaho

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators Surveys & Controls
Moderator: F. Honing

Name	Insect species: Douglas-fir tussock moth	Insect species: Budworms	Insect species: Larch casebearer	Insect species: Loopers	Insect species: Other (specify)	Fields of work – Control: Microbials, biocides	Fields of work – Control: Parasites, predators	Fields of work – Control: Chemicals	Fields of work – Control: Cultural	Fields of work – Control: Other (specify)	Fields of work – Surveys: Impact	Fields of work – Surveys: Detection and population surveys	Fields of work – Surveys: Sampling method development	Fields of work – Surveys: Other (specify)	Comments: Please specify the nature of your work
Russell W. Clawson	x			x							x	x			Impact of chemicals with potential as DFTM control agents on numbers of nontarget lepidopterans and their parasitoids part of DFTM Program.
Max M. Ollieu	x	x					x	x			x	x			Participate in aerial and ground detection surveys, do impact evaluations for top kill, mortality and growth loss.
E. Hlady		x	x		MPB				x		x	x			Administrative Input detection and Control procedures
A. Van Sickle	x	x		x							x				Damage appraisals
Jack Monets	x	x		x								x			CFS Forest Insect & Disease Survey, Victoria
Ken Lister		x					x	x							Forest Insect Suppression
Henry Yangs	x	x	x	x	MPB			x							Forest Development Rep. Northwest Registration of Products for Forestry

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators Surveys & Controls
Moderator: F. Honing

Name	Insect species: Douglas-fir tussock moth	Insect species: Budworms	Insect species: Larch casebearer	Insect species: Loopers	Insect species: Other (specify)	Fields of work, Control: Microbials, biocides	Fields of work, Control: Parasites, predators	Fields of work, Control: Chemicals	Fields of work, Control: Cultural	Fields of work, Control: Other (specify)	Fields of work, Surveys: Impact	Fields of work, Surveys: Detection and population surveys	Fields of work, Surveys: Sampling method development	Fields of work, Surveys: Other (specify)	Comments: Please specify the nature of your work
Harold L. Osborne	x								x			x			Site/Stand Condition and Douglas-fir Tussock Moth
Bill Seabrook		Eastern								Pheromones					Sensory physiology and behavior

WORKSHOP: WHO IS DOING WHAT IN DEFOLIATOR RESEARCH

Moderator: Gary Daterman

The primary objective of this workshop was to identify the individuals currently conducting research on western defoliators, and something about their particular studies. In making this review, the influence of the USDA Douglas-fir tussock moth R&D Program quickly became apparent since about 80% of western defoliator research currently involves the tussock moth. This observation triggered discussion on the "pros and cons" of R&D Programs. On the plus side it was the concensus that such programs were very beneficial through implementation of intensive team efforts on a particular problem. The major disadvantage of Programs seems to be the emphasis on short-term applied objectives, which is - to at least some degree - at the expense of the long-term more basic goals. A summary recommendation might be that program efforts are desirable in getting lots of people working together on the same problem even if it is short-term; however, at least a "maintenance" level long-term effort should be continued beyond the life of the program on selected studies.

Problem selection or orientation of programs was another point of discussion. A majority of the workshop participants favored "crop" or ecosystem orientation, as opposed to targeting one specific pest. Thus, current program orientation would be on management of the Douglas-fir - true fir type rather than management of the Douglas-fir tussock moth.

Below are listed individual studies with investigator(s) and agencies. This list was meant to be as comprehensive as possible, although it is highly probably that at least some studies have been overlooked.

<u>POPULATION DYNAMICS: TUSSOCK MOTH</u>

(Study title)	Institution	Investigator
1. Interaction of Physical and Biotic Release of Douglas Fir Tussock Moth Populations	U/Wash	Fritschen Gara Walker
2. Chronology of Douglas Fir Tussock Moth Outbreaks and Climatic Factors	U/Wash	Brubaker
3. Genetic Polymorphism in the Douglas Fir Tussock	Wsu	Stock
4. Development of Models for Tussock Moth Population Dynamics and Tree and Stand Interactive Response	OSU	Overton Colbert

5.	Prey Identification in Polyphagous Predators of Douglas Fir Tussock Moth	OSU	Stephen
6.	Ecology of Parasites and Predators of the Douglas Fir Tussock Moth in the Pacific Northwest	U/Ida	Gittins Smith
7.	Investigation of Endemic Orgyia pseudotsugata with Emphasis on the Parasitoids, Predators, and Associated Pest Complex on White Fir, Abies concolor, in California	U/Cal	Dehlsten Schlinger Luck
8.	Update Atlas of Douglas Fir Tussock Moth Outbreaks in Region 1 (Montana, Idaho).	USFS/R-1	Ward
9.	Analysis of Douglas Fir Tussock Moth Distribution in Region 1 (Montana, Idaho)	USFS/R-1	Ward
10.	Non-destructive Sampling Procedures for Assessing Douglas Fir Tussock Moth Egg and Larval Populations on Ornamental Trees	USFS/R-3	Parker
11.	Douglas-Fir Tussock Moth Population Assessment Survey Using Pheromone Traps -- New Mexico	USFS/R-3	Parker Lessard
12.	Douglas-Fir Tussock Moth Population Assessment Survey Using Pheromone Traps -- Idaho, Nevada	USFS/R-4	Ollieu
13.	Douglas-Fir Tussock Moth Population Assessment Survey Using Pheromone Traps -- California	USFS/R-5	Wenz
14.	Douglas Fir Tussock Moth Population Assessment Survey Using Pheromone Traps -- Oregon, Washington	USFS/R-6	Trostle Meso
15.	Douglas Fir Tussock Moth Population Assessment Survey Using Pheromone Traps -- Montana	Mont	Kohler
16.	Pheromone Trapping for Detection and Monitoring of Douglas Fir Tussock Moth	FS/PNW CFS/V	Daterman Sower
17.	Douglas Fir Tussock Moth Population Assessment Survey Using Pheromone Traps -- Idaho	IDL	Livingston Shepherd

18. Analyzing Short-Term and Long-Range Effects of Douglas Fir Tussock Moth Defoliation and Tree Damage Impacts to Pacific Northwest Resources Using Sequential Aerial Color Photographic Sampling Techniques	USFS/R-6	Wear Trostle
19. Tree Damage Caused by Different Population Densities of the Douglas Fir Tussock Moth	USFS/PNW	Wickman
20. Host/Insect Interactions and Population Dynamics of the Douglas Fir Tussock Moth	USFS/PNW	Beckwith
21. Species Interactions and Bionomics of Parasites and Predators Attacking Douglas Fir Tussock Moth and Associated Insects	USFS/PNW	Torgerson
22. Dynamics of Low-Level Populations of the Douglas Fir Tussock Moth	USFS/PNW	Mason
23. History of DFTM Infestations in California	USFS/R-5	Wenz

SITE CONDITIONS STAND CHARACTERISTICS : TUSSOCK MOTH

24. Influence of Defoliation on Stress Physiology of Grand Fir and Subsequent Attack by Bark Beetles--Contribution to a Tree Mortality Model	WSU	Berryman
25. An Evaluation of the Impact of Forest Defoliation by Douglas Fir Tussock Moth and Subsequent Managment Activities on Future Site Productivity	WSU	McNeil
26. Vegetation Succession Following Defoliation of Forest Stands by the Douglas Fir Tussock Moth	WSU	Zamora
27. Effect of Deforestation by Tussock Moth on Timing, Quantity and Quality of Streamflow and Stream Productivity Parameters	CWSC	Swanger
28. Defolaition: Its Effect on the Growth of Douglas-Fir	OSU	Webb
29. Identification of Site and Stand Factors Related to Susceptibility to DFTM-by aerial photography	U/IDA	Heller

30.	Implementation of Douglas Fir Tussock Moth Defoliation Impacts Into a Stand Prognosis Model Using an Individual Tree Simulator	U/Ida	Hatch
31.	Comparative Studies on the Physiological Environment Indices of Grand Fir Stands Located on High, Moderate, and Low Douglas Fir Tussock Moth Hazard Sites in Northern Idaho	U/Ida	Stoszek
32.	Characterization of Susceptible Stands	USFS/R-5	Wenz
33.	Implementation of Prognosis Model for Forest Stand Development for Combined Assessment of Silvicultural and Douglas Fir Tussock Moth Control Activities	USFS/Int	Stage
34.	Determination of Incidence, Extent, and Rate of Decay Associated with Dead Tops Killed by the Douglas Fir Tussock Moth	USFS/PNW	Aho Wickman
35.	Site Index and Height Increment Functions for Inland Douglas-fir Developed from Stem-Analysis Data	USFS/INT	Monserud
36.	Estimates of Gross Net and Managed Yields of Eastside	USFS/PNW	Cochran
37.	An Evaluation of the Impact of Forest Defoliation by Douglas Fir Tussock Moth and Subsequent Management Activities on Future Productivity	USFS/PNW	Klock
38.	Effect of Deforestation by Tussock Moth on Timing, Quantity, and Quality of Streamflow and Stream Productivity Parameters	USFS/PNW	Helvey Tiedemann
39.	Effect of Defoliation of Mixed Conifer Stands on Rainfall Interception Loss, Snow Accumulation and Melt, and Precipitation Chemistry	USFS/PNW	Tiedemann Helvey
40.	Evaluation of Impact of Douglas Fir Tussock Moth Defoliation in Douglas fir Stands on the Nez Perce National Forests in Idaho	USFS/R-1	Ward Bousfield

CONTROL METHODS: TUSSOCK MOTH

41.	Impact of Chemical Control Applications in the Forest on Beneficial Insects	WSU	Johansen Akre Turner
42.	Preparation of Microbial and Other Biological Insecticides	WSU	Spence
43.	Small Mammal Responses to Experimental Pesticide Applications in Coniferous Forests	BYU	Jorgensen Smith Booth
44.	Regulation of Bud Bursting Time of Douglas-Fir and Grand Fir	OSU	Newton
45.	Monitoring the Effects of Chemical Control of the Douglas Fir Tussock Moth on Selected Non-Target Insects	U/Ida	Smith Gittins
46.	Evaluation of the Sex Pheromone as a Control Agent for Douglas Fir Tussock Moth	USFS/PNW	Sower Daterman
47.	Ground Applications of Microbials	USFS/PNW	Stelzer
48.	Aerial Field Experiment with *B.t.*	USFS/PNW	Stelzer
49.	Temperature Effects on *B.t.* Infection	USFS/PNW	Stelzer
50.	Deactivation of *B.t.* on Coniferous Foliage: Factors Affecting Fate of Insecticide Deposits with Special Reference to Antibacterial Substances and Volatile Principle in Foliage and UV Irradiation	USFS/PNW	Stelzer
51.	Development of Improved Formulations for Microbial Insecticides	USFS/PNW	Neisess Stelzer
52.	Safety Evaluation of Virus Preparations	USFS/PNW	Martignoni
53.	Virus Identification	USFS/PNW	Martignoni Hughes
54.	Mixed Virus Infections of Tussock Moth	USFS/PNW	Hughes
55.	Variation of NPV Strains	USFS/PNW	Thompson Hughes

56.	Epizootiology of NPV	USFS/PNW	Thompson
57.	Laboratory Screening of B.t. Strains	USFS/PNW	Thompson
58.	Testing of Microbial Formulations for Field Applications	USFS/PNW	Orchard
59.	Testing Possible Improvements in B.t. Spray Formulations	USFS/PNW	Thompson Stelzer Neisess
60.	Bioassay to Provide Supporting Data For Design and Execution of Tests	USFS/PSW	Robertson
61.	Residue Analysis for Carbaryl, Dimilin, and Orthene as Part of the 1976 Safety Tests	USFS/PSW	Pieper
62.	Field Experiments to Determine Efficacy of the Insecticide Dimilin	USFS/PSW	Hard
63.	Safety Tests of Selected Chemicals on Non-Target Organisms	USFS/PSW	Shea
64.	Metabolism and Breakdown of Orthene	USFS/PSW	Crisp
65.	Airborne and Fallout Drift of Pesticide Sprays Under a Forest Canopy	U/Cal	Akesson
66.	Effects of a Chitin-Inhibiting Insecticide on Mycorrhizal Fungi and Mycorrhiza Formulations	USFS/PNW	Trappe
67.	Epizootiology of the Nuclear Polyhedrosis Virus of the Douglas Fir Tussock Moth	USFS/PNW	Thompson
68.	Ground Application of Selected Insecticides on Douglas Fir Tussock Moth Populations in Montana	Mont DNR&C	Kohler
69.	Chemical Identification and Bio-assay of Tussock Moth Pheromone and Other Natural Chemicals Influencing Behavior or Development	OGC	Daves
70.	Effect of Experimental Insecticides on Insectivorous Birds in Forest Environments	F&WS	Henny

71.	Collection Efficiencies of Foliage, Insects, and Artificial Samplers	OSU	Cermak Wedding
72.	Biochemical Studies on the Viruses of *Orgyia pseudotsugata*	OSU	Beaudreau
73.	Pilot Test of Chemical Insecticide Orthene to Determine its Efficacy Against the Douglas Fir Tussock Moth	USFS/R-6	FS
74.	Control Strategies in B. C.	CVS/V	Shepherd

SOCIOECONOMIC EVALUATION: TUSSOCK MOTH

75.	The Economics of Tussock Moth Impacts and Control Alternatives	U/Wash	Schreuder

PEST MANAGEMENT SYSTEM: TUSSOCK MOTH

76.	Integration and Synthesis of Douglas Fir Tussock Moth Data	USFS/PNW	Campbell

WESTERN SPRUCE BUDWORM

1.	Effectiveness of new strains of *B.t.*	USFS/PNW	Thompson
2.	Attractiveness of pheromone blends to western spruce budworm.	CVS/V USFS/PNW	Sanders Shepherd Daterman
3.	Correlation of pheromone-trapped moths and subsequent defoliation.	USFS/PNW USFS/R-6	Daterman Meso
4.	Impact studies	CFS/V	Van Sickle
5.	Predisposition for Barkbeetle Attacks	CVS/V	McMullen
6.	Genetic Differences in Budworms as Determined by Electrophoresis.	U/IDA	McDermott
7.	Computer Simulation of Western Budworm in B. C.	CFS/V	Thomson
8.	Control of *Choristoneura* with *B.t.* and sublethal doses of insecticide.	U/SF	Hodgkinson

WESTERN HEMLOCK LOOPER

1.	Identification of the looper complex in the coastal Hemlock/Douglas-fir type	USFS/PNW	Mitchell
2.	Biology of the Principal Species in the Looper Complex	USFS/PNW	Mitchell
3.	Pheromone Bioassay and Related Studies	USFS/PNW	Sartwell
4.	Biological Control of Loopers	U/Cal	Dahlsten

LODGEPOLE NEEDLEMINER

1.	Long-term population monitoring of lodgepole needleminer in central Oregon	USFS/PNW	Mason

LARCH CASEBEARER

1.	Introduction and establishment of Parasites	USFS/PNW USFS/Int	Ryan Denton
2.	Sampling System to Appraise Populations of Casebearer	UBC	?
3.	Evaluation of Parasites Effectiveness	USFS/PNW USFS/Int	Ryan Furniss
4.	Population Dynamics and Impact Studies	USFS/Int	Furniss Denton
5.	Native Parasites of Casebearer; Biology and Behavior	U/Ida	Hensen
6.	Live Table Development	U/Ida	Brown

BLACKHEADED BUDWORM

1.	Population Dynamics and Modeling	CFS/V	Shepherd
2.	Pheromone Trapping for Population Densities	CFS/V	Shepherd

OTHER SPP.

1.	Growth and Economic Impact of Spear-marked Black Moth in Alaska	USFS/PNW	Werner

2. Biology and Behavior of *Zeiraphera* sp., a defoliator of eastern larch in Alaska.	USFS/PNW	Werner

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators: Research
Moderator: G. Daterman

Name	Insect species: Douglas-fir tussock moth	Budworms	Larch casebearer	Loopers	Other (specify)	Fields of work: Population ecology	Sampling	Attractants	Host relationships	Behaviour	Physiology	Parasites, predators	Associated microbes	Other (specify)	Comments: Please specify the nature of your work
Roy Shepherd	x	x	x	x		x	x	x		x		x			Population ecology, insect behavior, sample system control strategy of B.C. defoliators.
Chris Sanders		x				x	x	x		x		x			Sex pheromone, endemiology of budworm, general population ecology of budworm.
Tom Gray	x	x		x		x	x	x		x		x			Population dynamics, attractants, sampling in B.C.
Terrel McDermott	x	x												Biochem.	Genetic comparison of spruce budworm eastern and western forms, the same with Douglas-fir tussock moth (these programs under Dr. Stock at Univ. of Idaho)
Robert Hodgkinson		x			Pine Weevils	x	x			x		x	x	Aerial Application	Master of pest management student - Simon Fraser University Integrated Control of Choristoneura fumiferana with B+ sublethal doses of insecticides. Plot selection and aerial application.
Daphne Fairbairn					Water Striders	x				x	x			Genetics	Currently looking at evolutionary adaptations of insects to variable environments. Interested in applying this approach to forest defoliators, particularly to dispersal strategies.
Alan Thomson		x			Bark Beetles	x				x	x				Computer simulation of western budworm in B.C. and models of bark beetles, mistletoe, root rot.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators: Research Moderator: G. Daterman	Insect species					Fields of work									Comments
Name	Douglas-fir tussock moth	Budworms	Larch casebearer	Loopers	Other (specify)	Population ecology	Sampling	Attractants	Host relationships	Behaviour	Physiology	Parasites, predators	Associated microbes	Other (specify)	Please specify the nature of your work
Robert F. Luck	x				x	x	x			x		x			Scale, Needle miner, biological control of tip moth.
Kurt Volker	x	x		x		x			x	x		x			Survey and study of parasitoids of DFTM (and alternate host species at endemic levels)
Boyd Wickman	x					x			x						Study of tree and stand damage and modeling pop. Ecology of DFTM.
Anthony Thomas		x								x	x				Moth Dispersal, Physiological age of 49 related to behavior and susceptibility to insecticides.
Mark Brown			x			x									Partial life table (egg to overwintering period) and distributional pattern of eggs on branch.
Andy Majowa	x														Responses of understory productivity following reduced density and stocking of Douglas-fir defoliation. Some impacts on tree growth and mortality.
Dan Dahlsten	x			x	x	x	x					x			Sampling and development of life tables for DFTM

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators: Research
Moderator: G. Daterman

Name	Insect species					Fields of work									Comments
	Douglas-fir tussock moth	Budworms	Larch casebearer	Loopers	Other (specify)	Population ecology	Sampling	Attractants	Host relationships	Behaviour	Physiology	Parasites, predators	Associated microbes	Other (specify)	Please specify the nature of your work
Bob Duncan		x				x				x	x				Simulation models (Tech. assistance)
Wm. Cooper	x			x		x	x			x		x			
M.W. McFadden	x	x				x	x	x	x	x	x	x	x		
						(integrative/management viewpoint)									
Jim Hansen			x									x			Finishing Ph.D. dissentation on the biology and behavior of Spiluchaleis albiframs, a native parasite of larch casebearer
Bill Seabrook		Eastern						x		x	x				
Bob Heller	x						x							Stand Dynamics	Identifying stand and site characteristics which are related to susceptibility to DFTM
Jim Colbert	x													x	Modeling of outbreak population dynamics and the associated defoliation impacts.

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Defoliators: Research
Moderator: G. Daterman

Name	Insect species					Fields of work									Comments
	Douglas-fir tussock moth	Budworms	Larch casebearer	Loopers	Other (specify)	Population ecology	Sampling	Attractants	Host relationships	Behaviour	Physiology	Parasites, predators	Associated microbes	Other (specify)	Please specify the nature of your work
Skeeter Werner						x		x	x	x		x			Biology and behavior, impact on growth, food reserves, effect defoliation on nutrient cycling. Field testing pheromones.
Gary Daterman	x	x					x	x		x					Pheromones - general I.D., etc. Field application of pheromones for survey and control.

Pests of Young Trees
Moderator: Ch. Sartwell

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Name	Insect species	Field(s) of work eg; attractants, popn ecology, etc.	Comments Please specify the nature of your work
Les McMullen	P. strobi	Biol. and ecol.	Simulation
David Voegtlin	aphids	Taxonomy - Biology	Taxonomy Cinara arthropod survey of old growth Douglas-fir canopy
Doug Ross	Black vine weevil	Surveys	
Valin Marshall	Collembola	Taxonomy Control	Control of Bourletiella hortensis in bare root nursery
LeRoy N. Kline	All	Survey, evaluation and control	Survey, evaluation and control
Bruce H. Roettgerine	All	Survey, Evaluation and Control	Survey, evaluation and control
Richard H. Hunt	All Forest Insects	Administration of a Pest Control Program	Detection, evaluation and control
Ken Donkersley	All	All Forestry Activities	All Forestry Activities
Tom Koerber	Rhyacionia and Eucosma Tip Moths	Biology and control	Life cycle and habit descriptions and tests of insecticides and phermones.
Harold L. Osborne Karel Stoszek	All Eucosma sp.	Survey, evaluation of young cultures	Survey, evaluation of young cultures
Lee Campbell	All esp. Rhyaciona Vespamina, adelgids, root weevils	Control, biology, attractants, resistanc	Basically ornamentals, Christmas trees

CURRENT ENTOMOLOGICAL ACTIVITIES OF WORKSHOP PARTICIPANTS

Name	Insect species	Field(s) of work eg; attractants, popn ecology, etc.	Comments Please specify the nature of your work
John W. Dale	Those damaging tropical tree species	Ecology and silvicultural regulation	
Mary Ell Dix	Rhyacionia spp. Petrova spp., Seed & Cone Borers, hardwood defoliators	Biology, Control, Impact	Life cycle insecticides and biological control. Use of sex attractants
Larry C. Yarger	Any found during regeneration surveys	Regeneration surveys	
Clifford P. Ohmart	Air pollution & bark beetles	Effects of air pollution on tree growth and bark beetle interactions	Looking at applications of stand growth models, for predicting future of forests affected by air pollution.
Paul Gravelle	Inland NW spp. damaging conifer seedlings/saplings	Applied research for control of pest problems	Young stand management research - no entomol. research - just keeping informed of work being done.
Dave Overhulser	Eucosma. All pests of tree reproduction	Biology, tree resistance, insecticides, attractants	Biology and laboratory rearing of Eucosma sonomana Control of usbcortecal weevils in conifers.
Jack Walstad	Pests of Forest Regeneration	Silvicultural and chemical control	
Jim Kinghorn	General	Regeneration silviculture.	
Sergeif. Condrashoff	General	Control (esp. nursery insects) and fungal diseases - chemical and biological	development of new chemical application (safer Agro-Chem Ltd)
Charles Sartwell	Eucosma sonomana; Lambolina fiscellaria lugubrosa	Pheromones	development of pheromones for population measurement

WORKSHOP: SEED ORCHARD INSECT PROBLEMS
Moderator: Steve Cade
Participants: John Wenz, USFS-FIOM; Harry O. Yates, III, USFS SEFES; Alan Hedlin, Pac. For. Res. Centre; Don McMullan, B. C. Forest Products, Ltd.; Evan Nebeker, Mississippi State University; Doug Ruth, Pac. For. Res. Centre; Gary Haut, Pacific Logging; Don Pigott, MacMillan Bloedel; Anita Kuestich, PLC; Gord Miller, Simon Fraser University; C. A. Hewson, B. C. For. Service; G. M. Albricht, B. C. For. Service; Mike Meagher, B. C. For. Service; Ingemar Karlssan, B. C. For. Service; Tom Koerber, USFS.

Harry Yates presented a historical review of the cone and seed insect research program carried out by the U. S. Forest Service in the Southeastern Forest Experiment Station. The research program was started with two entomologists at Lake City, Florida in 1955. By 1972, the program had four additional entomologists in Athens, Georgia. Accomplishments of the program to date are as follows:

1. Identification, description, and life cycle information on cone and seed insect pests of southern pines.

2. Publication of cone and seed insect literature review and several publications.

3. Formation of the Southern Seed Orchard Pest Committee, with objective to develop and obtain registration for insecticides to control major seed orchard pests.

4. Registration of Furadan® granules.

5. Mechanization of Furadan granule application to incorporate material in soil.

6. Thirty-five additional insecticides have been laboratory screened against seed bug nymphs, with carbaryl, carbofuran, Dursban®, and Dylox® giving best control.

7. Future work will concentrate on applied controls, life tables, damage monitoring, insecticide screening, residue analysis, and translocation studies.

Al Hedlin said the approach to cone and seed insect control in Canadian conifers differed somewhat, since most insect pests

were vulnerable to control at one well-defined period of time. Control has relied on use of precisely timed application of systemic insecticides. Present and future work, however, is concentrating on testing the feasibility of using synthetic attractants to control insect pests. This is cooperative work with Dr. Weatherston at Sault Ste. Marie, and has involved testing of attractants for Barbara colfaxiana in Douglas-fir and Laspeyresia youngana in spruce. 9-dodecene-1-ol (98% trans, 2% cis) appears to be quite attractive to Barbara. Al Hedlin is also working with Harry Yates on a book of cone and seed insects of North America.

Tom Koerber presented recent data from a study he conducted on treating of individual Douglas-fir trees in northern California for cone and seed insect control, using Meta-systox-R in a Mauget Injector. Significant midge control and increase in sound seed was achieved using either 0.25 or 0.5 gm of insecticide per inch of tree diameter.

Steve Cade presented information on an insecticide screening trial for control of Dioryctria cone worm, conducted in the Weyerhaeuser Company Jefferson Seed Orchard in Oregon. Dimethoate, Guthion®, and Orthene® applied as 0.5% foliar sprays at monthly intervals all significantly reduced coneworm damage.

A discussion was generated around the question, "Should seed orchard insect problems be solved totally with chemical insecticides?" Most agreed that control with chemical insecticides was a necessary first step in order to quickly reduce damage to an acceptable level. When this has been accomplished, a more integrated approach should be pursued. Yates suggested that a greater reliance on insecticides may be necessary in the South than in the West due to their greater diversity of pests and longer growing season.

Seed & Cone Insects
Moderator: S. Cade

Name	Insect species: Cone and seed-feeding insects	Cambial-mining insects	Twig and tip-mining insects	Other (specify)	Fields of work: Attractants	Insecticides	Cultural practices	Population ecology	Other (specify)	Comments: Please specify the nature of your work
Alan Hedlin	x	x	x		x					Laboratory and field testing of synthetic and natural set attractants. Bud and tip mining and cambial mining insects in seed orchards.
Steve Cade	x		x		x	x	x			Improving Seed Orchard Seed production. Reducing impact of terminal feeding and regeneration insects.
Harry Yates	x					x		x		Work in these areas are being conducted by six forest entomolgoists in Athens
Mary Ellen Dix	x		x			x		x		Insects affecting Shelterbelts in Great Plains. Including shelterbelt establishment, etc.
John Wenz										FIDM Role in developing pest management strategies for seed and cone insects in California.
Tom Koerber										Tests of injectable insecticides for control of Douglas-fir seed insects.
Shane Weber	x						x			Testing the effect of shelterwood cutting on populations of insects infesting Grand fir seeds and cones.

WORKSHOP: HOST REACTION TO STEM ATTACKS BY INSECTS
Moderator: Malcolm Shrimpton

Current work in this field throughout B.C. and North Western U.S.A. is following two distinct directions: cellular studies of defense processes, and the relating of bark beetle attack patterns to fluctuations in tree condition as determined from varying moisture stress and resinosis. On the basis that tree and insect exist in a dynamic balance, the need for work on this subject was seen as improving the capacity to predict large scale tree death.

Work on the cellular processes that effect resistance is in progress at the Pacific Forest Research Centre. Bir Mullick described some of the basic anatomy and the processes he is studying that effect repair of the tree's outer protective layers and the cork and vascular cambium. George Puritch described the production of pathological heartwood and rotholz, in Abies, and the relationship between moisture stress and the process of tissue repair by damaged bark. Malcolm Shrimpton described the major differences between resin secreting tissues of spruce and pine in relation to bark beetle attack. A mimeographed summary of the studies was distributed.

On the subject of field trials to evaluate resistance and relate it to insect attack, George Ferrel , Pacific S.W. For. and Range Exptl. Sta., described experiments on inducing moisture stress in standing trees and the compensatory responses that occurred within those trees. Larry Wright, Washington State University, Pullman, described his thesis work on the problem of evaluating tree resinosis in a field setting and the relating of this evaluation of beetle success for a stand. Karel Stocek, University of Idaho, Moscow, discussed his results on evaluating stand health by means of pressure bomb measurements.

Group discussion centred on the problem of effectively measuring tree resistance and expressing this on a stand basis. Much information on the defense processes of coniferous trees has been gained in recent years. It has also been shown experimentally that moisture stress, of the order of that frequently measured in forest trees in late summer, can prevent or retard defense processes. However, the way moisture stress affects cellular defense processes and the internal adjustments that occur in trees in response to increasing stress are poorly understood.

WORKSHOP: HOST RECOGNITION BY INSECTS
Moderator: Tom Payne
Panelists: Bill Seabrook, Henry Moeck
Fred Stephen

Bill Seabrook covered host recognition by lepidopterous pests. The topic was covered under three headings.

1. Host Attraction: This is a long range attraction to the plant and is both visual and olfactory.

2. Oviposition Stimulants: These cues are both contact chemosensory and tactile. In some Lepidoptera, both the chemistry of the secondary plant products found on the leaf surface and the texture of the leaf are important.

3. Feeding Stimulants: These stimulants are primarily gustatory and perceived through contact chemoreceptors. In some instances, however, olfactory signals are also required for successful feeding.

Long range attraction brings the moth or butterfly to the potential host plant for the purpose of feeding and/or oviposition. Whether or not the insect remains on the plant, or immediately departs, will depend on the presence of adequate oviposition stimulants and/or feeding stimulants.

Henry Moeck covered host recognition by bark- and wood-feeding Coleoptera and Hymenoptera (families Scolytidae, Cerambycidae, Buprestidae, Curculionidae and Siricidae). Host selection by these tree-infesting insects occurs with respect to tree species (one, few or many), to the anatomical part of the tree (roots, stem, branches, foliage), and tree condition (healthy, dying, dead or decaying) for the purpose of maturation feeding and/or oviposition. Stimuli which may be used by insects in host selection are visual (tree or stem contours or silhouettes), olfactory (volatile chemicals), gustatory (non-volatile chemicals), or special (e.g. infrared radiation from burning trees detected by some *Melanophila* species).

Information was presented on field experiments on host selection carried out in California, 1970-73. Materials tested were untreated and anaerobically treated ponderosa pine bolts, sugar pine bark and ponderosa pine bark. In these tests very few Scolytidae were trapped. Field tests with trees predisposed to bark beetle attack by cacodylic acid injection and lower stem freezing with dry ice, and naturally predisposed by root infection by *Verticicladiella wagenerii*, with tree screening to prevent beetle attack and pheromone production, indicated that of the Scolytidae trapped, only *Gnathotrichus retusus* appeared to orient to susceptible trees. Other species apparently landed at random, indicating that host selection occurs on the tree itself. Siricidae also appeared to be attracted to susceptible trees.

Current experiments with the spruce beetle, *Dendroctonus rufipennis*, indicate that it is able to orient to suitable host material (cut spruce bolts) by means of olfaction. Laboratory work is in progress to isolate and identify the primary attractant(s).

Host recognition by beneficial insects was covered by Fred Stephen. The presentation pertained to aspects of host recognition with a limited group of insects, natural enemies of the Scolytidae, particularly Dendroctonus spp.

It was pointed out that scolytid natural enemies are exceptionally well adapted to their hosts. This is not necessarily in the sense that they are able to regulate their hosts' density at sub-economic levels, but rather in the ecological sense. The rationale for this statement was explained with several examples. Scolytid natural enemies are always found with their hosts. Even with very isolated single trees which are attacked, the natural enemy complex will be present. In areas which have been newly colonized by certain scolytids, their natural enemy complement has kept pace with their movement northward. An example was given using the southern pine beetle which has only been detected in Arkansas since 1969, and in certain counties since 1976. Natural enemy populations that have been sampled here, appear to be of at least equal density as those areas in the south where the beetle has long been endemic. Other examples were given which also pointed out the highly developed sense of host habitat finding by scolytid natural enemies. The arrival patterns of the various parasite and predator species are well timed to put a maximum number of them near the host at a point in time at which the host is most susceptible (either for oviposition or active predation). The factors responsible for this well timed arrival may be in response to certain components of the beetles pheromones (e.g. Temnochila and Thanasimus) or to unknown products possibly associated with a particular stage of decomposition within the tree, or secondary attractants produced by the natural enemies themselves.

It was noted that although host specificity does exist, the complex of bark beetle natural enemies remains remarkably similar in species composition and possibly ecological roles between different bark beetle species.

Slides were shown presenting the results of research on western and southern pine beetle natural enemies which illustrated the influence of such factors as host-tree species, temperature and rainfall, season of the year, tree bark thickness and texture on host recognition by scolytid natural enemies.

WORKSHOP: COMPUTER ANALYSIS OF HISTORICAL FOREST INSECT SURVEY DATA

Moderator: John W. E. Harris

Eight participants met to discuss the above topic, but concentrated for the most part on the collection of data, in which some of them were involved or interested. The problems caused by lack of consistency of data collection methods over past years, and by analyzers failing to recognize deficiencies in the data when performing analyses, seemed to be of greatest concern. Conclusion: long-term sampling schemes should be well planned and documented so that future workers can correctly interpret them. In spite of deficiencies, seen by hindsight, data can still be useful if their limitations are known.

The moderator updated the participants on recent developments in the Canadian Forest Insect and Disease Survey (F.I.D.S.) data collection and retrieval system. In B. C., a number of standard computer programs now permit the extraction of information quickly. An on-line, interactive system is being developed and one year's data are loaded; new data are being added to the system as they become available. The best use of this system seems to be for acquiring information quickly and for planning more extensive retrievals.

The data in B. C. are good, and while not detailed enough for many studies, should serve to guide more "in depth" research and help predict future gross changes. Population fluctuations were clearly definable and correlations with data from standard weather stations are the next goals. The F.I.D.S. system principally records pest populations but some attempts now are being made to add tree damage. The participants agreed that the measuring and predicting of pest impact was something that all systems should include, and possibly should receive the major emphasis. B. C.'s forest inventory system is presently being computerized. Some of the problems in integrating systems are different computers and different systems for defining locality. Nevertheless, the somewhat utopian concept of linking population and damage records with an overall forest inventory system appears to be coming closer.

WORKSHOP: SIMULATION MODELS OF FOREST INSECT-STAND INTERACTION
Moderator: Alan J. Thomson

Three simulation models developed at the Pacific Forest Research Centre were demonstrated. The first model, presented by L. McMullen and developed by him in collaboration with R. Quenet, simulates the interaction of Sitka spruce and the spruce weevil. The host response to attack was illustrated. The main impact on the tree is to kill the leader, whereupon the tree replaces the dead leader with competing laterals. Varying degrees of competition and growth rate following attack and their effect on weevil population and stand growth were examined.

The second model, developed and presented by A. Thomson, illustrated the method for handling dispersal in a model of the western budworm in the mountainous terrain of British Columbia. At present, our knowledge of the wind patterns in the budworm outbreak area, and the flight behaviour of the moths in relation to these wind patterns, is extremely limited. However, the model allows the effects of a wide range of wind patterns and flight behaviour to be examined by simulation. The impact of these different dispersal processes is illustrated by changes in the severity and spatial pattern of defoliation.

A third model, presented by L. Safranyik and developed by him in collaboration with C. Simmons, illustrated the effect of tree susceptibility on the population dynamics of the spruce beetle. Tree susceptibility in the model is a function of site characteristics, rainfall in the present and previous years, and the incidence of windfalls in the stand.

WORKSHOP: PROBLEM ANALYSIS AND DEVELOPMENT OF CONTROL STRATEGY
Workshop Coordinator: H. Tripp

Conference participants were presented with background information on a current insect outbreak by the workshop coordinator. Following this, the participants were divided into five groups and charged with the task of developing short- and long-term guidelines to manage affected stands. At the end, the groups reassembled for a discussion of the guidelines that were developed in the five workshops.

TWENTY-EIGHTH WESTERN FOREST INSECT WORK CONFERENCE

Minutes of the Final Business Meeting
March 1-3, 1977

Victoria, B. C.

Chairperson Johnsey called the meeting to order at 8:40 a.m.

Minutes of the inital business were read and approved.

Motion was passed to accept the invitation of the Colorado Delegation to hold the 1978 meeting at Durango, Colorado on March 7, 8, and 9. Charles Minnemeyer will be Program Chairman.

Chairperson Johnsey expressed gratitude to the Program Committee consisting of Malcolm Shrimpton, Chairperson; Les Safranyik, Roy Shepherd, Les McMullen, Tara Sahota, John Harris, Stu Whitney, Dave Dyer, and Al Hedlin. A round of applause was received from the membership.

The 1979 meeting site was discussed. Mark McGregor suggested Missoula, Montana and Max Ollieu suggested Boise, Idaho. This item was tabled until the 1978 meeting.

Boyd Wickman initiated discussion from the initial business meeting relating to what should be included in the proceedings. After discussion, Galen Trostle made a motion not to include the workshop minutes in the proceedings. The motion failed to pass. Therefore, proceedings will remain as in the past.

During the above discussion, John Harris suggested that the list of people and what they are doing from the workshops "who is doing what in forest entomology" be included in the proceedings.

The topic of student registration was brought to the floor and discussed. A motion was made but failed to pass to refund the current $4.00 student registration fee.

Mike Atkins continued this theme and made a motion to keep student registration fees as low as possible. Motion passed.

Malcolm Shrimpton reviewed the costs of this year's conference.

Chairperson Johnsey called for committee reports:

<u>Common Names Committee</u> - None. Material covered during initial meeting.

Nominating Committee: The committee of Henry Moeck, Ken Graham, and Bill Ires submitted the name of John McLean to replace Les Safranyik as the Canadian Councilor. There being no nominations from the floor, John was elected by acclamation.

Ethical Practices Committee: Chairperson Molly Stock listed "events" that took place during the conference. Several people seemed worthy of the award, but finally decided upon Dave Culhain to be the new chairperson.

There being no further business, the meeting was adjourned at 9:20 a.m.

TREASURER'S REPORT

Twenty-eighth Western Forest Insect Work Conference
Victoria, B. C.

Balance on hand February 28, 1977		$ 135.04
Receipts:		
Received from registration	$2,909.66	
Sell of extra proceedings	3.50	
	$2,913.16	$3,048.20
Expenses:		
Princess Mary Restaurant (Banquet)	1,097.25	
The Empress Hotel (room fees, etc.)	258.20	
Oak Bay Parks & Recreation (curling)	96.00	
Wise Way Transportation (buses)	193.76	
Miscellaneous	20.88	
Bank charges (Canadian-U.S. exchange)	9.90	
	$1,675.99	$1,372.21
Balance on hand April 25, 1977		$1,372.21

WESTERN FOREST INSECT WORK CONFERENCE

MEMBERSHIP ROSTER

Note: Members registering at the Victoria, B.C., Conference March 1-3, 1977, are indicated by an *.

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